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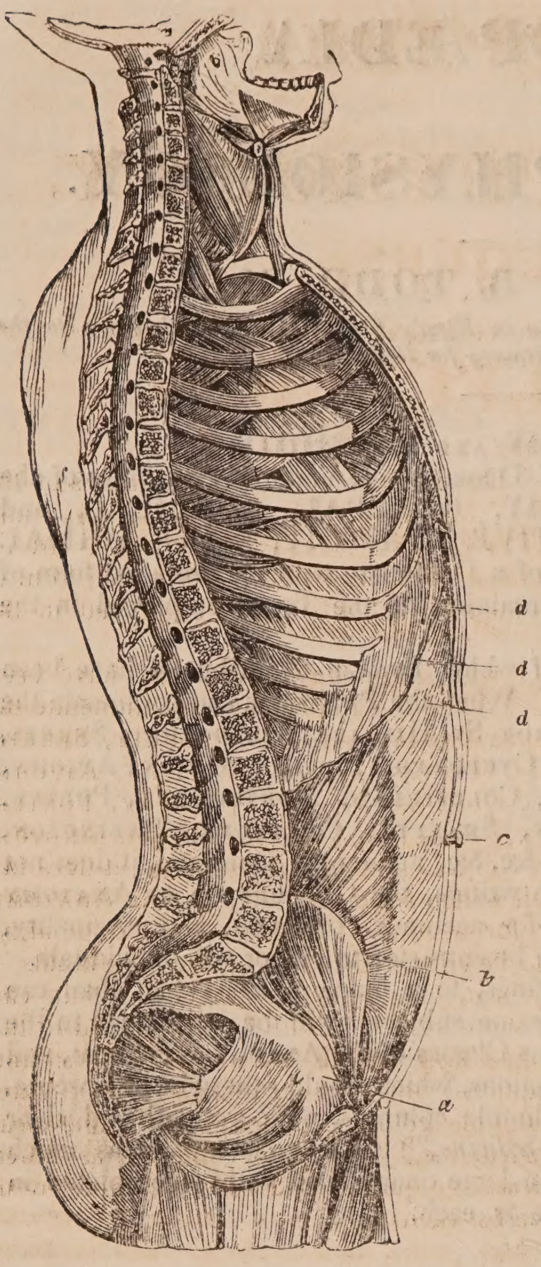
[*Specimen of the Work, see over.*

Fig. 320.



AVES.

Order I. *RAPTORES.*

Body, very muscular.

Beak, strong, curved, sharp-edged and sharp-pointed, often armed with a lateral tooth; upper mandible the longest. (*Fig.* 112.)

Fig. 112.

Legs, robust, short, with three toes before, and one behind; all armed with long, strong, crooked talons. *Fig.* 113.

Fig. 113.

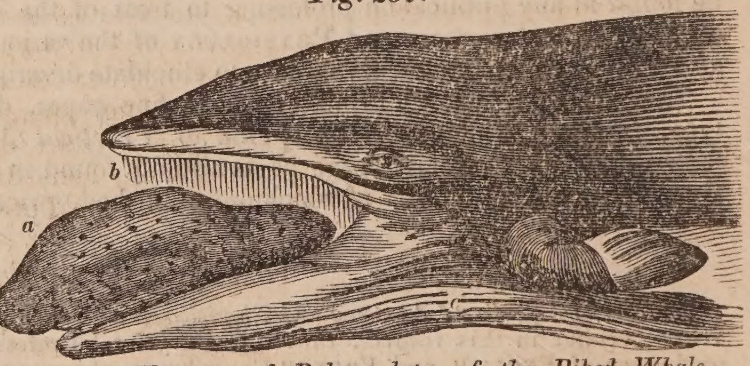
All the Birds of Prey feed on the flesh of living or recently killed animals. They have a prompt, powerful, and rapid flight. They are monogamous; the female exceeds the male in size. They nidificate in lofty situations and rarely lay more than four eggs: the young are excluded in a blind and feeble state.

Abdominal Cavity, (in human anatomy.) The annexed woodcut exhibits a vertical section of the body intended to show the thoracic and abdominal cavities, from which the viscera have been removed. A simple reference to it and to *fig.* 204 will sufficiently explain the form and boundaries of the latter cavity, which have been already fully described in the article Abdomen. Our object in the present article is to examine the abdominal cavity as it is brought under the eye of the anatomist, when its contents have been exposed by removing or cutting through the abdominal parietes.

It rarely happens that we meet with an instance in which the abdominal viscera have not been more or less disturbed after death from their natural relations to one another. During life the contractile walls of the abdomen, ever active, maintain such a uniform degree of pressure on the contained organs, that displacements or alterations of positions are very rare occurrences excepting through some preternatural opening in the abdominal parietes. It is advisable to study the positions of the contents of the abdomen in a body recently dead, and which has not experienced any degree of disturbance.

CETACEA.

Fig. 259.



*Tongue and Baleen-plates of the Piked Whale, Balænoptera Boops.**

The tongue itself corresponds to the form of the space included by the rami of the lower jaw, and is consequently of great size in the Cachalots and Balænidæ, rising in the latter like an immense cushion (*a*, *fig.* 259), into the space between the laminæ of baleen (*b*), and affording a great quantity of the finest oil. In the figure it is represented in the Piked Whale, but probably preternaturally enlarged and raised by the extrication of gas caused by putrefaction. It is thick, and its free extremity is generally short, but this is less remarkable in the *Phytophaga* than in the *Zoophaga*.

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* From Fr. Cuvier, *Cetacea*, pl. 20.

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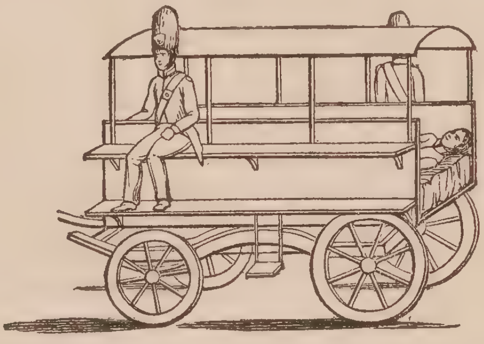
This spot should be distinguished by a black flag for its protection, as pointing out a neutral ground consecrated to the general cause of humanity; this signal should invariably be respected by besieged and besiegers, and in no instance should works be carried on under its protection, or ammunition secured. The flag should be struck the moment the ground becomes a military post. All storming or escalading parties will be followed by a sufficient number of surgeons and bearers, with torches and lanthorns to be lighted when required. When the besieged fortress is carried by storm, the wounded in the breach may be hoisted on the ramparts in cots slung from beams projecting from the parapet. This will be found more expeditious and less distressing than carrying them back over the counterscarp, to go round by the town gates.

In a besieged town.—Here the spring-waggons and cars are useless, and their horses only increase the consumption of forage. The wounded should be carried away by the hospital corps in carriages belonging to the town, or on bearers; the sick and wounded should be accommodated in public buildings, on which a black flag is to be planted, in a situation easily discerned by the besiegers during the day, and reflecting lanthorns will designate it in the night. During a bombardment, the wounded had better be secured in bomb-proof casemates, and medical officers should be on permanent duty both day and night, and detachments of the hospital corps stationed at every point of attack, whether in the outworks, or in the fortifications of the body of the place.

When a breach is rendered practicable, the surgeons of the garrison, with the hospital corps, should assemble in the vicinity, in some safe building. Should the storming party be repulsed, the wounded left in the ditch and on the breach should be removed over the ruins by means of planks fixed on a gangboard, and laid down as a platform; a truck moving upon four low wheels, in grooves, and lowered by a windlass, will be found most convenient for this humane purpose. In night-attacks it would be desirable that, by a mutual agreement, signals by rockets, for a short cessation of hostilities should be thrown up, that the wounded might be collected and borne away: their situation after an assault is truly deplorable,—heaped up with the dead, amongst ruins, most probably wet through from wading across the fossé, and generally very severely wounded; the delay of a few minutes is to these unfortunate men of vital importance. It is needless to add, that the *matériel* of the ambulance or hospital corps must vary in description according to the features of the theatre of war. In mountainous tracts, our waggons and cars will be useless, but wherever field-pieces and the pontoon train can move, our wheeled transports can follow.

The same observation applies to our medical stores, which must be more or less abundant, according to the state of the country. In populous and fertile provinces, local supplies may be provided, but in an abandoned and impoverished land it must be obvious that all the wants of the wounded that are not previously foreseen, will be sadly felt in the hour of need; and while we should not encumber ourselves with useless medicines, we should not dread even a superabundance in our surgical means of relief.

Fig. 8.



Model of a light spring-waggon for bearing the badly wounded off the field. Those slightly wounded are placed on seats each side of the waggon.

(*J. G. Millingen.*)

AMENORRHŒA (from α, priv., μὴν, a month, and ῥέω, I flow,) has usually been considered under two heads, *emansio* or retention, and suppression of the menstrual secretion; the former implying its non-appearance at the usual period of life, the latter, its interruption after it has become established.

In viewing the important function of menstruation physiologically, we are struck with many of its phenomena at once peculiar and interesting, and among others, those which may be considered concomitants, or rather precursors of its first appearance. From an early period in the history of medicine up to the present time, writers on physiology have observed, that in warm countries, as in some parts of Asia and America, puberty in the female occurs as early as the ninth or tenth year, whilst in the colder regions, as in Lapland, it may be retarded to the eighteenth or twentieth year. In this temperate climate the uterus begins to perform the function of menstruation when the female arrives at the age of fourteen or fifteen. It must not be overlooked, that the first irruption of the secretion does not depend on climate alone, but on a perfect development of the generative system. The uterus and ovaries must have assumed the characteristics of the adult, and a correspondent change must have taken place in other and distant organs. In a pathological or curative point of view this circumstance is of no ordinary moment.

In investigating the pathology of amenorrhœa, there are two conditions of the whole economy which demand careful consideration; one in which the system has morbidly arisen above the natural standard, the other, where it has sunk below it, and when with an appearance of general debility, there is often to be found local congestion, producing a torpidity of the uterine capillaries. The healthy and morbid conditions of the various functions of the body, but more particularly of the chylopoetic viscera, require careful observation, as the non-performance of the healthy action of the uterus after development may, for the most part, be traced to disturbance in the general health. It is true that constitutional derangement is sometimes the *consequence* of suppressed catamenia; and the cause of retention may be found in the structural alteration of some part of the uterine system, as an imperfect formation or occlusion of the os uteri, cohesion of the labia, or vagina, or imperforate hymen. The menstrual fluid may have been duly secreted, and its escape prevented by one of the organic causes mentioned, but particularly the latter. In such a case, puberty will have become developed, but the patient is found with enlargement of the abdomen, besides various pelvic and abdominal symptoms, which taken altogether, frequently excite an unjust suspicion of pregnancy. The structural peculiarity in the hymen, can only be detected by examination, when a small crucial opening by means of a scalpel or lancet will allow the secreted fluid to escape, and afford an alleviation to the sufferings of the patient. In interrupted functions of the utero-vaginal system which do not yield to judicious treatment, a careful examination should be made by the touch. It is generally unfortunate for the female when from a too fastidious delicacy, whether on the part of the practitioner or patient, this inquiry is neglected. Again disease may exist in some distant organ or tissue, as, for instance, in the lungs, liver, &c., when the functions of the uterus will become interrupted, and can only be restored by the original cause being removed.

The female having gone beyond the period of life when the first appearance of the catamenia might have been anticipated, if a plethoric condition of the system obtains, it may be easily recognised. Headach, vertigo, or a sense of weight in the head, with occasional throbbing, flushing of the face, thirst, and a quick accelerated pulse, are the most prominent characteristics of a loaded circulation. This condition of the system may be protracted, but it is usually of short duration, and the general health sinks into the second state before alluded to, a state eventually productive of important functional and structural derangement. In this case the hue of health will have vanished from the cheek, pallor prevails, generally with a darkness about the eyes, and partial tumidity of the face; and in what may be called the second stage, together with these appearances, a tinge of the icterode or yellowish green colour is so obvious in the countenance, that the term chlorosis or green sickness has been given to the disease. The tongue, at first white and loaded, becomes red, and not unfrequently, its papillæ enlarged. The appetite is singularly affected; and it is common to find in the patient an unconquerable desire to eat lime, chalk, earth, sand, and other substances equally indigestible and improper; in short, the digestion becomes imperfect, and a deteriorated condition of the blood with a loss of vital energy are the results. The patient is now almost incapable of exertion, she is subject to dyspnœa, with a short irritable cough, which, together with frequent accessions of pain in the chest, or sides, create in the minds of her parents or friends considerable apprehensions for her safety.

In promoting a healthy action of the uterine system, whether the case be one of retention or suppression, the condition of the circulation demands early attention; and where there is an excess of action in the pulse, with headach, a furred tongue, hot skin, and other symptoms of undue excitement, the means required should be those usually included in the term antiphlogistic. It is comparatively easy to accomplish the first object in view, that of lowering the system—would it could be said to a standard of health. General bleeding, not objectionable as a powerful remedy in some cases, should be employed with caution; but the local abstraction of blood, by means of leeches to the groins, or by cupping glasses applied over the sacrum, may be had recourse to, oftentimes with great advantage. These, together with active purgation, and a vegetable diet, may be the means of producing the wished for discharge.

Fortunately for the sex, pathological inquiry, with its results, has superseded bigotry and false principles; and a revolution may be said to have taken place in the treatment of amenorrhœa. To the experienced physician, a restoration of the patient's general health is his primary object; this accomplished, there is oftentimes little more to be done. These remarks are applicable to both retention and suppression. The latter may be classed under two heads, the acute and chronic. From exposure to cold, some violent mental or bodily exertion, or from some trivial accident a few days or hours before the menstrual period, the discharge does not appear as usual, or is suddenly arrested even after the period has commenced; this may be called the acute obstruction, and will be attended by a quick pulse, pain in the region of the uterus, a sense of bearing down, thirst, headach, and other symptoms of pyrexia, and occasionally with some degree of hysteria. It may be requisite, under such circumstances as are here described, to have recourse to the lancet; but in the abstraction of blood, we should be governed by the system of the patient, and the urgency of the symptoms. Local bleeding, under ordinary circumstances, will be preferable, as already suggested. Purgatives of an active kind should be given, and the hip-bath may be used with advantage. Should there be much pain in the region of the uterus, together with spasmodic or hysterical symptoms, camphor, combined with hyoscyamus or opium, will be useful. These measures, however judiciously employed, will not always prove successful in securing a return of the discharge.

In amenorrhœa, from interrupted functions in the various organs, and consequent decline of the general health, whether in the youthful or adult female, a plan of treatment of some continuation will become necessary, which plan may with propriety be classed under the following heads:

1. Mild and continued purgation. 2. Exercise in the air, as much as the patient can bear without fatigue. 3. The warm hip-bath or pediluvium. 4. A rigid system of dietetics. 5. Medicines which assist in promoting a healthy digestion. 6. Medicines which are supposed to possess the power of exciting the secreting vessels of the uterus.

1. The value of the Hamiltonian system of purgation will be almost universally admitted in amenorrhœa. Who has not oftentimes seen it produce the long-looked-for discharge, without an auxiliary remedy? Of the warm stimulating aperients which act on the lower part of the intestinal tube, probably aloes is the best, in the form of the compound decoction, or the aloetic pill in combination with rhubarb. Purgatives should be administered with great regularity, that the bowels may be acted upon freely, but not powerfully. The degree of debility in the digestive apparatus should be the principal guide in the choice of aperients, care being taken that too great a depression of the vital energies does not ensue from an excess of alvine discharges.

2. For the promotion of health in the various secretions, any of the active exercises in the open air when the atmosphere is dry and cool are highly important. Walking, moderate dancing, (not in hot rooms late at night,) horse-exercise, &c., gradually increased in frequency and force, without inducing much fatigue, should be practised with regularity, notwithstanding it may be necessary to enforce it against the inclinations of the patient, whose bodily and mental faculties will probably have become languid and inactive. If the system be greatly impaired, the passive exercises, as riding in a carriage, or sailing, should be substituted.

3. Twice or thrice in a week the warm hip-bath, at about 95°, for a quarter of an hour, should be used, after which, friction with a soft brush or flannel, will prove serviceable; indeed, when from circumstances the kind of exercises alluded to are unattainable, a valuable substitute for them will be found in general friction; it promotes a glow and perspiration, and tends greatly to increase the energy of the frame.

4. The diet should be light and nourishing, and the quantity moderate at each meal. Stimulating drinks are generally to be avoided, but in some cases a glass of good Madeira, sherry, or a little mild ale may be taken daily, provided it does not occasion headach, or preternatural activity in the circulation.

5. When the functions of the stomach are disordered, aromatic bitters will often prove of service, either alone or combined with steel. Probably one of the best forms in which steel can be administered, is the Mistura ferri composita. The cardialgic symptoms, if troublesome, may generally be removed by the liquor potassæ subcarbonatis. A course of chalybeate waters may be tried, their efficacy being aided by the society and amusements which, at public watering places, can be usually obtained.

6. In the medical treatment of amenorrhœa much confidence has been placed in the various stimulating medicines termed Emmenagogues, from their being thought capable of exciting the uterine vessels. In their exhibition care must be taken that the system be placed in a state fit to receive them. If the vital actions be too low, or on the other hand, if they be much excited, emmenagogues, always of doubtful utility, are inadmissible. Madder, savine, hellebore, guiacum, iodine, secale cornutum, strychnine, &c., have all in turn been extolled; they are, however, more calculated for suppression than retention of the catamenia.

In married females, or widows, the local remedy recommended by Lavagna may be tried; it must be considered, however, as secondary to general treatment. Ten or twelve drops of the aqua ammoniæ puræ in an ounce of milk and water, (or of sufficient strength to produce some degree of irritation) are to be thrown into the vagina twice or thrice a day.

Galvanism and electricity have been employed with success; and the tourniquet has been applied round the thighs for the purpose of causing a greater determination to the vessels of the uterus; the latter plan has met with but few advocates.

In amenorrhœa, blood is occasionally discharged from the nostrils, nipples, bowels, or sometimes from an ulcer, which seems intended as a substitute for the catamenial secretion to keep up the balance of the circulating fluids; this has been designated vicarious menstruation.

(*George Jewel.*)

AMMONIA, MURIATE of, *hydro-chlorate of ammonia, sal ammoniac*, syn. *muriat d'ammoniaque*, Fr.; *Salmiack*, Ger. The name *ammonia* is derived to this substance from the circumstance of its being formerly procured from Ammonia, a district of Egypt, in which was situated the temple of Jupiter Ammon. It used to be obtained by subliming the soot formed by burning camels' dung. As chemistry advanced, it was derived from other sources, and was commonly prepared by adding sulphuric acid to the volatile alkali obtained from soot, bones, and all the offal of large towns, mixing it with common salt, and subliming it. It is now obtained in great abundance, and at a very cheap rate, from the ammoniacal liquor resulting from the distillation of coal to form gas.

In the liquid state, ammonia is highly caustic, and produces powerful effects on the animal economy. When applied to the skin, it produces, according to its state of concentration, and the duration of its contact, a slight degree of rubefaction, or vesication by the extravasation of serum, under the epidermis, or the formation of an eschar; three of the stages of burns. The *pommade de Gondret*, which consists of equal parts of ammonia, and mutton suet, previously melted at a slow heat, possesses all these properties. Soon after it is applied, it produces redness of the skin, with pain and heat, and in fifteen or twenty minutes, the epiderm is raised into a blister, corresponding in extent to that of the application; if it be continued for sometime longer, an eschar is formed. In this preparation, therefore, the practitioner has a double resource,—first of a blister, in cases where the action of cantharides might be dreaded; secondly, of a moxa, for persons who dread that species of application too much. But whether alone, or in conjunction with unctuous substances, it deserves to take an important place amongst the stimulants of the skin; and is often employed as a resolutive in indolent engorgements, in chronic inflammation of the lymphatic ganglions, glands, and even of the fibrous and osseous tissues; and as a revulsive, in neuralgic and rheumatic pains. For the mode in which it is employed in these cases, see Paris's *Pharmacologia.*

As a caustic, it is advantageously employed in poisoned wounds, as it decomposes the venom, and destroys, at the same time, the parts in which it had been deposited. When the patient refuses excision, or when excision is impossible, after the bite of a serpent, or rabid dog, it may deserve consideration, whether the liquid ammonia should not be preferred to the iron, at a red or white heat.

One of the great advantages to be held in view, as regards this substance, is the power it gives the surgeon of varying the intensity of its effects according to the object he has in view; thus, when he is afraid of inflammation, he may expose the parts for a few moments to the vapours of the ammonia; in acting on an amaurotic eye, for instance. In liniments of various kinds, its effects are moderated by its combination with oils, in the proportion of a drachm or two of the ammonia to an ounce of oil; thus conjoined, it forms a liquid soap, with which frictions are made on the skin for various indications. M. Larrey, who frequently employs the incandescent iron in his hospital practice, often pours liquid ammonia on the eschar, with a view to lessen the pain produced by the application of the heated iron.

Lavagna has recommended it in the form of an injection into the vagina, in amenorrhœa. For this purpose, he mixed ten or twelve drops of the ammoniacal liquor, with an ounce of warm milk. The injection is used three or four times in the day. He has often succeeded in this manner in bringing on the catamenia, in the space of one, two, and at furthest in five or six days. The practice, however, is not resorted to, by English obstetricians. It has also been found beneficial in cases of simple leucorrhœa.

AMMONIAC, *ammoniaci gummi*, L. *ἀμμονιακὸν*, Gr., *Ammoniak*, Ger., *gum ammoniac*, Eng. The derivation is the same as that of the preceding term. The ammoniac is a gum resin, obtained by the hardening of the milky juice that flows from the *heracleum gummiferum*, a plant which grows in the sandy plains in the interior of Morocco. By more recent writers, however, especially M. Fontanier, who saw the plant growing at Yezd-Cast, in Persia, it is said to be derived from some of the species of *Ferula*, and is called by Lemery, *ammonifera.*

Its use in external application is now much restricted, but it has enjoyed great reputation as a discutient in scrofulous and indolent tumours, particularly in the vicinity of the joints. Combined with mercury it forms the *emplastrum hydrargyri cum ammoniaco.* When dissolved in vinegar, and evaporated to a proper consistence, as in the *emplastrum ammoniaci*, it is sufficiently stimulant to produce an inflammation, and papular eruption of the skin.

AMPULLA, Lat.; *ampoule*, Fr.; a small blister, or elevation, caused by the effusion of serosity under the epiderm. It is sometimes used by English authors, and universally by French, to designate the small blisters which are observed on the feet and hands, from long walking, pressure of shoes, or severe labour, such as rowing, &c.; in such cases, they are mere watery pustules, of greater or less extent, over which the sense of touch is enfeebled or totally destroyed. But they are also occasioned sometimes by sudden and violent pressure, as, for instance, when a part is pinched between two hard bodies; the serosity in the latter case, instead of being clear, is bloody, and the colour of the ampulla is dark red.

In the heat of summer, they often occur, even from slight pressure on the heel or toes; owing to the great resistance of the epiderm in these situations, it is elevated so uniformly that their existence is not recognised until they produce tension and pain. When they are extensive, and the epiderm strong, the serosity may be retained so long that its qualities are altered, and it becomes very fetid; if small, the watery effusion is absorbed. In general, it is best to empty the ampullæ by making small punctures; in the extensive ones, an incision should be preferred: the soreness and inflammation arising from the retention of the serosity, should be soothed by a poultice after the removal of the macerated epiderm: the inflammation once abated, compresses wet with a solution of acetate of lead will suffice for the cure.

Their appearance has some resemblance to the phlyctenes of a burn or scald, but they are at once distinguished from them on referring to the cause that produced them.

(*Wm. B. Costello.*)

AMPUTATION, from *amputare*, to cut off; *amputation*, Fr.; *Abnehmung*, *Absetzung*, Ger., signifies the operation of cutting off a limb, or a portion of a limb. This is the proper surgical meaning of the term, in its usual, though somewhat restricted acceptation, and the only one to be attached to it in this article. We say restricted, because the term has other significations. Thus, *resection*, or the cutting off the ends of bones; the removal of the lower jaw, in whole or in part; the excision and extirpation of soft parts, such as the tonsils, the testicle, the uterus, and still more appropriately, the penis, are operations often termed amputations.

The word amputation is also sometimes used as a generic term, including all the abovenamed significations; and then it is synonymous with *ablation* and *apharesis* (see these words) which, in this sense, are more suitable, and more frequently employed.

Amputation is a subject of such great extent and importance, that it is highly desirable in attempting to treat it fully, to arrange the matter belonging to it,—the various and multitudinous topics it embraces, in an order which will prevent omissions, and serve to impress it well on the understanding.

General remarks on the limbs.—The subject before us involves topics of the highest importance. Such is the nature and structure of the limbs, their importance to life, and the enjoyment of life, that the responsibility of the surgeon who removes or curtails them, can hardly be overrated. We deem it, therefore, right to make some brief reference here to their anatomical conformation, their uses, and their vital importance. Organs of more or less complex and varied motion, of general and often of special sensation, the limbs, considered with regard to the wide and philosophical meaning of anatomical structure, are evidently all modelled upon the same type, in all animals. Modified to suit the habits and destiny of the being to which they belong, they seem to become more and more important comparatively with the rest of the body, as well as in comparison with the same parts in other animals, in proportion to the importance of that being in the animal scale.

From the nature of their functions it follows that they must be composed of substantially different parts, arranged so that the combination shall assume a form varying according to the purpose it has to answer, but always more or less elongated.

The muscles are evidently the most important and characteristic of these constituents. The muscular tissue may be considered as the essential as well as the most abundant element of the limbs, as of every other organ of motion: these muscles being under the direct and immediate influence of the nerves which, as it were, confer upon them, in a great degree, their motile faculty; the nervous tissue is the element, at least second to, if not equal in importance with the muscular.

In the third place, the limbs have their framework, or skeleton, properly so called, which being otherwise almost inflexible, is subdivided, in general, transversely, into pieces made to move upon each other, and upon the trunk, by joints. This, their passive or mechanical part, seems to be their least essential constituent,—a mere sub-stratum; for we find it absent in organs destined almost exclusively to the purposes of motion, such as the tongue of most animals, and the proboscis of the elephant. It is certainly subordinate to the other parts, and formed of an element which, although it may be considered the universal material of organization, is always subordinate or passive also—the cellular tissue. Finally, we see entering into the composition of the limbs, for the purpose of sustaining their general organization, arteries, veins, and lymphatics, which convey to and fro the materials of their nutrition. Muscles, nerves, bones, vessels,—these, then, united by cellular tissue, enwrapped by a fibrous sheath with more or less numerous partitions, and covered by the skin, are the parts with which the surgeon has to deal in amputation.

In surveying the animal kingdom, as we ascend the scale, we find the limbs and their constituent parts, or immediate elements, becoming more and more complex and important, and each part apportioned in quantity and development to the uses for which it is designed: where strength is required, we find the passive; where agility, the more active elements predominating; and where a special sensation resides, we see an appropriate modification of parts to admit of that also.

In this survey we also find the limbs becoming less and less mere appendages, less and less independent of the body, or more and more essential or integral parts of it, as we examine them from an animal of less to an animal of greater importance; and it will be found that, in the same animal, the relative degree of importance, and therefore the danger and detriment of the removal of any particular limb, as compared with the others, may be appreciated by a reference to its anatomical composition, to the importance and relative quantity of its anatomical elements.

The increasing vital relation between the trunk and the limbs, and the proportionately increasing severity of the loss or removal of the latter, appears to be an important law which holds good generally, from the animal possessing the power to reproduce these appendages, to that in which the amputation of one of them is so severe as to threaten life. Exceptions will of course be found where modifications are required for particular cases; where an animal may have two or more of its limbs extraordinarily developed or extraordinarily diminished to suit its particular habits and destiny. In the case of greater development, the connexion of such limbs with the trunk, and the severity of their removal would be greater than in that of the general rule; and in the opposite case, less.

With strict regard to the philosophy of anatomy, perhaps the limbs may be considered, even in all animals, as the elements of the trunk prolonged. But if this view be taken of them in the lower animals, how much more strongly and completely may it be said of them in animals of a higher order. In man, and in most of the mammalia, the limbs, strictly speaking, are but prolongations of the trunk. Are not their nerves prolongations of the nervous matter of the trunk? Their arteries, veins, and lymphatics the selfsame tubes as those of the body prolonged into them? And do not the filaments of the great sympathetic, which creep along these vessels, connect the limbs to all the other parts of the body, internal and external, in the same manner as they connect and harmonize the viscera among themselves?

It is so, and on this account it would be no fiction to declare that amputation of both thighs at the hip-joints, is in some respects almost like the removal of one half the body.

We are convinced that the surgeon who appeals to his anatomical knowledge will take this view of the limbs, and feel that they are more, much more than mere contiguous appendages of the body. He will not allow the notion of lopping off a branch to save the trunk, to take too great possession of his mind, and prompt him to untimely amputations; but, on the contrary, will exert his best energies to combine means and chances with a view to heal and save both.

Not to mention their vital importance, their intricate and beautiful construction, how ornamental as well as serviceable are they! What a difference does man present when we contemplate his body possessed of these valuable endowments, and when we see it shorn of the least portion of them! Disguise as you will the loss of limb, the deformity must be great. Not even the sentiments which endear to us those who have sustained such a loss in defence of what we deem most worth the sacrifice are sufficient to symmetrize to our view the mutilated person of the most gallant hero. We look upon the sailor who has lost a limb in the service of his country with feelings of regard and sympathy. But neither these, nor the triumphant feeling that his life and honourable scars attest the power of surgery, can counterbalance the painful commiseration excited by the cruel curtailment of his person, and stifle the rising sense of shame and regret that it should still be necessary to employ the arts of war to mutilate mankind, and outrage the noblest work of the Creator.

Historical Notice of Amputation.—By the history, or historical notice, of an operation, surgical writers generally understand little more than a brief sketch of the changes it has undergone, with the mention of the names of the authors of those changes, and of the periods at which they have been effected; and in this signification only the title of the present section is intended to stand.

The natural separation of the limbs in cases of mortification first taught mankind that curtailments of the body might be borne without loss of life, and would sometimes be a means of preserving it. The same lesson might have been learned from the accidental tearing off of a limb (in which case there is no hæmorrhage,) but it is probable such an accident had no share in introducing amputation into surgical therapeutics; because by the earliest writers on surgery, and even by those who flourished as late as the thirteenth and fourteenth centuries, the operation is mentioned only in connexion with cases of mortification. Those authors did not dream of amputating except in cases of gangrene.

Hippocrates, who says but little on amputation, appears to have been of opinion that the operation was first suggested by the natural separation of the dead from the living parts after mortification. What he states concerning it is, as far as it goes, like most of his statements, correct and valuable. He indicates the chief danger of amputating to arise from syncope (induced, he undoubtedly means, by loss of blood,) and advises as most likely to prevent hæmorrhage, the adoption, after the operation, of a cool, light regimen, and the horizontal or rather elevated position of the stump.

The first description of what may be called a *method of amputating*, is given by Celsus. It is a remarkable but undeniable fact, that in many parts, the surgery of this author is scarcely inferior to that of the present day. His plan of amputating is decidedly the best proposed up to the time of Jean Louis Petit; and, indeed, some of the precepts given in it must ever form part of the rules for performing a good amputation. He states that the soft parts are to be divided down to the bone between the living and dead ones, but so that some of the former be removed rather than any of the latter should remain, and so that the incision fall not against a joint; that they are then to be drawn back and dissected off so as to leave some of the bone bare; and that the latter is to be sawn through close to the flesh adhering to it. But although in his fifth book, Celsus directs us, in cases of obstinate hæmorrhage from wounds, to tie the bleeding vessels in two places, and then to divide them between the ligatures, he does not appear to have known that the ligature, or any other efficient means might be used for preventing or stopping hæmorrhage in amputations; for he not only omits recommending any, but confesses that the patient often dies from loss of blood during the operation; and there is nothing in the manner in which he directs the stump to be dressed calculated to stop the bleeding from it.

Archigenes is supposed to have rendered amputation more safe from hæmorrhage than his predecessors, by tying the principal vessels with a ligature, either passed through, or embracing the whole limb, to which he also applied cold water. He was thus enabled to perform amputation in the living parts, which he appears to have been the first boldly and decidedly to practise. He took pains to save the skin by fixing it back before beginning the incisions; cauterised the wound with a hot iron after the operation; and then removed his ligature. He probably used the actual cautery to stop the bleeding from the small arteries; and when he speaks of tying or sewing blood-vessels, he probably means those of considerable size only. The measures of Archigenes were adopted by Heliodorus, whose opinion was unfavourable both to the hasty removal of the limb by a direct uninterrupted section, without drawing back and dissecting up the soft parts, and to amputations performed at the joints.

Galen says very little on amputation. He defended, however, the operation performed at the joints, on the ground of its being, in his opinion, safe and speedy.

Paulus Ægineta, whose name is often mentioned in connexion with amputation, cannot be said to have contributed to the improvement of the operation. He deviated from the precepts of Celsus, by insisting on the necessity of amputating in the dead parts, or only on the confines of the living ones. Among the Arabian surgeons the operation certainly underwent no improvement. It seems, on the contrary, to have somewhat retrograded; for Abúl Kasem recommended that the soft parts should be divided with a knife heated to redness, and that a balsam of sulphur should be applied afterwards to determine the separation of the eschar. Avicenna, however, repeated the rules given on the subject by the Greeks, and directed the incisions to be made rather above the gangrenous parts.

During the middle ages no improvement was effected in amputations. The few changes introduced were rather in a contrary direction. Theodoric di Cervia had the merit of recommending the method of Celsus. Prior to the operation he administered opium and hyoscyamus, with a view of rendering it less painful to the patients whom he afterwards endeavoured to rouse from the effects of the narcotics, by causing them to smell of vinegar and aromatics. Guido di Chauliaco, who lived about the middle of the fourteenth century, was more willing to allow gangrenous limbs to separate of themselves than to employ the knife. He used to enwrap the sphacelated part in pitch plaster, and to exercise such constriction as he considered calculated to facilitate its separation at the place of a joint.

In the sixteenth century, Hans de Gersdorf joined to the operation of Celsus, which he justly extolled, the proceeding of Archigenes, of fixing back the integuments with a band tied round the limb above the place of amputation. He would not use the actual cautery; and instead of employing the suture, which was beginning to be adopted in his time, he enveloped the stump in a pig's bladder.

About this period Maggi indicated the importance of having sufficient skin to cover the stump.

Up to the time of Ambroise Paré, as the means familiar to his predecessors were unsatisfactory, some of them, with Fallopius, employed the actual cautery, while others, among whom was Fabricius, Ab Aquapendente, continued, like Paulus Ægineta, to amputate in the gangrenous parts. Paré, the great surgeon of Louis XIV., introduced the plan of arresting hæmorrhage after amputation, by tying the vessels; a plan of so much importance that it may be considered to have led the way to every improvement the operation has undergone since his time. He used to draw out the vessels from the surface of the wound with a kind of forceps (bec de Corbin), and tie them with a double thread; just, says Boyer, as we are in the habit of tying the umbilical cord. In case the hæmorrhage returned, he employed a needle, and passed a ligature round the bleeding vessels, so as to embrace with them some thickness of the neighbouring tissues, and also a portion of skin, on which he placed a compress, and then tied the knot. Besides introducing the important measure of tying the bleeding vessels of the stump, Paré was the first who explicitly stated that a band should be tied tight round the limb, prior to amputation, not only to raise the skin and benumb the part, but also for the purpose of preventing hæmorrhage during the operation. Of this remarkable man, then, it cannot be too much to say, that he was the first who devised measures to enable surgeons to perform amputation safely, and thus laid the foundation of every improvement made in the operation since his time. As soon as surgeons obtained the power of controlling the circulation, through the discoveries of Paré, they were no longer obliged to hurry through the operation, through terror at the thought of the patient's bleeding to death, but were enabled to turn their attention to the shape to be given to the stump; they also began to think of applying amputation to other cases than those of gangrene.

A new era in surgery may be said to have commenced from the discoveries of Paré; and, as may be supposed, they were too great an innovation to meet with ready or general adoption. Many of his contemporaries, and even some of those who came after him, neglected to give their patients the benefit of these measures, which, combined with the method of Celsus, constituted a better kind of amputation than any which had preceded it; and such was the operation performed by Fabricius Hildanus, and Wiseman. Fabricius introduced the use of the retractor; and, like Paré, after tying the principal vessels, applied the actual cautery to the surface of the stump. Wiseman did not make use of the retractor. He sometimes employed the actual cautery, and sometimes tied the vessels. In either case, he afterwards applied a suture and a compressive dressing of stiff plaster. He joined Fabricius Hildanus in advising that the incisions should always be made in the living parts. Dionis rejected the actual cautery. He was averse to amputation performed at the knee-joint.

Towards the end of the seventeenth century, Lowdam of Oxford, and Verduyn of Amsterdam insisted on the necessity of dividing the soft parts obliquely, so as to cut them into a kind of flap, adapted to cover up the end of the bone; and thus may be said to have originated a kind of oblique or flap amputation. This mode was opposed by Koernerding and Heister, and defended by Messuet of Leyden, while La Motte operated after the manner of Wiseman and Dionis.

Munichs endeavoured to revive the system of amputating in the joints, which happily had been rarely employed since the time of Guido di Cauliaco. He was equally unfortunate in preferring styptics to the use of the ligature.

The next great improvement to that of Paré was made by Jean Louis Petit. More completely master of the circulation than his predecessors, by the use of the superior tourniquet he invented, he could direct his attention still more exclusively than they, to the form to be given to the wound by the incisions; and to him is due the honour of affording the patient something like security against that frightful evil—a badly shaped stump. He invented the method of dividing the soft parts by two incisions, limiting the first to the skin, allowing this membrane to retract, and then dividing the muscles. Petit was also one of the first who advocated the propriety of amputation for incurable aneurisms and certain cases of caries and gun-shot wounds.

Shortly after the invention of this method of operating, Ledran performed amputation, for the first time, at the shoulder-joint; and Garengeot, Lafaye, and Sharpe proposed plans of executing the same operation.

About the same time, Remi de Vermale and Ravaton revived the kind of amputation proposed by Lowdham and Verduyn, and which, it appears, had been indicated, among the ancients, by Heliodorus. They modified it, however, so much as to make in it two flaps, instead of one; and from them, therefore, the flap operation, as it was adopted by Dessault, and is now usually performed, may, perhaps, fairly be said to have taken its origin.

At this period of the history of amputation, names thicken upon us. Many of the questions relating to it were treated of scientifically by Monro, Guénaud, Blomfield, and others; but no important change appears to have been projected, until Louis propounded his doctrine with regard to the unequal retraction of the muscles. Upon this he proposed to alter the operation of Petit, by making the first incision divide both the skin and superficial muscles, and the second the deep muscles only; a plan very like, if not the same as that upon which Ledran was accustomed to proceed.

It had often been a question with surgeons what cases ought to be treated by amputation; and from being agitated at the Académie de Chirurgie, it was generally discussed at this period, and among others, by Boucher, Faure, Morand, Bilguer, and Shunuker. Shortly after, a good deal was said of amputation in the joints, and surgeons were bold enough to perform it at the hip. Morand was one of the first to describe this operation scientifically.

In 1779 Alanson proposed a plan of amputating, the novelty of which consisted mainly in the dividing the muscles obliquely upwards towards the bone, by one sweep of the knife; but of which the chief merit lies in the measures it prescribes for preserving a sufficient quantity of skin to cover the whole surface of the stump. His mode of cutting through the muscles was found very difficult, if not impracticable; but the publication of his observations had considerable and perhaps the chief influence in introducing the practice of dressing the wound so as to cause it to unite by first intention. Although this practice is generally attributed to Alanson, Benjamin Bell justly claims some share of the merit of it, in his description of amputation, where he states, that from the year 1772 he laid it down as a maxim not to be deviated from, to save as much skin and cellular substance in the removal of tumours, whether cancers or others, when the sound parts admitted of it, as would completely cover the sores; and in amputating any of the extremities, to save as much of them as would entirely cover the stump. At all events, this plan of causing the stump to heal by first intention—and no fading laurel it is—belongs to English surgery.

It was adopted by Hey, and very soon by most of the British practitioners, whose amputations thus became more successful than those of the surgeons of other countries.

In the method of operating described by B. Bell, who, for the complete and scientific manner in which he treats of amputation, takes the lead of his contemporaries, the plan of preserving skin enough to cover the entire stump is combined with Celsus's mode of cutting through the muscles. The manner of dividing the muscles by layers, as now adopted, is generally attributed to Dessault; and it is certainly mentioned as his practice, in his works by Bichat, although the case of amputation of the fore arm there recorded as an illustration of it, does not present a methodical description of that part of the operation exactly as it is executed at the present day. All the three last named surgeons employed straight in lieu of the old curved knives, and dispensed with the band, which before their time it was the general custom to tie round the limb, either to benumb the part, or to mark the line of incision.

In the modern method of amputating, the skin is preserved for covering the whole of the stump, and the muscles are divided by as many distinct incisions as there are layers. It is only true to say, that from the time of Alanson, English surgeons have ever been distinguished for the excellence of their amputations. They, more strictly than any others, adhered to his rules for preserving the skin; and these, combined with the present mode of dividing the muscles, constitute the best possible kind of circular amputation.

The history of amputation, while it exhibits evidence, both of the reluctance that exists in some minds, from an adherence to customary practice, to adopt what is new; and of the disposition in others, from the desire of change, to undervalue what is old, still offers, as to ultimate results, an instance of the positive though slow advance of science. The operation has ever been influenced by the general state of surgical knowledge, and has varied accordingly; but nothing contributed so much and so directly to its improvement as the discovery of the means of preventing hæmorrhage.

As may be observed with regard to almost every branch of art and science, this part of chirurgical therapeutics has had some intervals of stagnation, and even of retrogression. Upon the whole, however, its periods of change have been those of amendment; and, although sometimes stopped or misdirected in its course, it has at last attained that degree of perfection from which, we trust, it will never recede, and beyond which, it may be difficult to make it advance.

Classification.—Amputations differ from each other in many respects. It will be found they may be best arranged according to the method of performing them, and according to the limb and part of the limb at which they are performed. There is more than one method of amputating applicable to every or almost every part. Each plan which is of such general application that it can be applied to any part, may be properly termed a *general* method. For example, the amputation of any part may be performed so as to leave a wound with one or more elongated portions of soft parts, called flaps, for covering and healing over the bone which remains; and when so performed, it is termed the *flap amputation.* This being applicable to every, or almost every limb and part of a limb, constitutes a *general* method. The same may be said of the plan in which the soft parts are left of the same length all round the limb, and which is called the *circular* method; and the same of that which, from the form of the wound, is termed the *oval* method.

As each limb or part of a limb may be removed by more than one method, there are as many individual amputations as distinct parts to be amputated, multiplied by the number of methods, and modifications of methods, or processes applicable to them.

We understand, then, by a *general method* a mode of amputation applicable to every, or almost every part; and by *individual amputation*, the amputation of some distinct part, by each or any method or process considered separately.

There are certain considerations which apply to all methods of amputating, and to all amputations, taken in the aggregate; and which, to avoid repetition in the treating of each of them, and in order that the reader may have the whole subject clearly before him, we shall present first and together: while whatever applies solely or more particularly to each *general method*, or *single, individual amputation*, taken separately, will be noticed under the head of that general method, and of that special amputation.

As the first considerations apply generally to all amputations wherever, or by whatever plan performed, to general methods and to individual amputations, they ought to precede the description of both. The different general methods of amputating as applicable to any part, come naturally, and will be treated of next in order; and, lastly, we shall treat of every individual amputation of every part, by each and every method and modification of method which has been devised.

CASES IN WHICH AMPUTATION OUGHT TO BE PERFORMED.

In treating of amputation, most authors endeavour to point out the diseases for which it should be performed. But it is evident that a general statement, made with this intention, can be but an enumeration, of little use to the practitioner, and that he ought to look upon it as scarcely more than a catalogue or table, showing at once the number of disorders, or species of cases, for which the operation is performed. Otherwise considered, or with any other importance attached to it, it might mislead the young surgeon. The proper place for pointing out each case requiring amputation, is that, where all the details concerning it can be most completely and minutely entered into; and that place clearly will be under the head of each disease, when we enter into the description of the treatment suited to each or any of its particular cases considered separately. What we ought, and shall more particularly attempt to do, besides making the above enumeration, is to lay down general rules to assist the surgeon in solving the difficult problem—for what cases ought amputation to be had recourse to? In order to come to as just a decision as possible, as to whether or not amputation should be performed, in any case under consideration, the surgeon must always proceed in the same manner. The great object is to calculate the consequences that must ensue, both with and without the operation: in order that of the two courses—its adoption, or rejection—that may be pursued which offers the greater number of chances in favour of the patient's life and health. We have to calculate on the one hand, the consequences of the disease treated by amputation; and on the other, its consequences treated without amputation. We have to compare the consequences on both sides, and to determine for the alternative which leaves the larger residue of probable good.

To solve the problem, all the data must be taken which the answers to the following interrogatories will furnish. What are the exact parts, and to what precise extent is each injured or diseased, taken anatomically, part by part? What are the usual effects, local and general, proximate and remote, of the lesion or disease affecting them? and what will they be in the case in question — that is, under the particular circumstances of the patient with regard to age, sex, physical, mental, and moral constitution, previous and present habits, place of abode, climate, season, and the care and attention that can be obtained for him? Having such data, the surgeon will be able to foretel the issue of a case with a degree of certainty proportionate to his pathological knowledge; and it is here that he will appreciate the value of a thorough acquaintance with pathology, and feel amply repaid for all the pains its acquisition may have cost him; for upon this only can he rely.

By nothing less than a systematic and elaborate investigation of all the circumstances of a case, can we expect to form an accurate opinion on the point in question. Let no man believe that his experience has endowed him with the power of judging correctly by any other method of proceeding. Let no man be tempted by the love of the marvellous to fancy himself a prophet. There must be no plunging at a conclusion: the shrewdest guess may lead to a woeful mistake; and nothing can be more reprehensible than yielding, in the least, to the suggestions of a spirit of divination or instinctive sagacity, which, if we proceeded without method, might have some influence, and in which a sort of self-complacency, derived from previous success, may sometimes induce us conscientiously to believe ourselves in possession of.

When the consequences which will ensue in any particular case, under the two modes of treatment,—that by amputation, and that without amputation,—(and, in considering the former, the shock of the operation must be taken into account,) have been correctly estimated and summed up, the surgeon has only to range them side by side, and to compare them. He will amputate where the consequences of the treatment by amputation establish the greater number of chances in favour of the patient's life and health; and he will not amputate where these chances are established by the treatment without the operation. This appears to us to be the rule by which he ought to be guided. Authors usually state that amputation ought only to be performed where the life of the patient cannot be saved without it. French writers express themselves to that effect[1]. But this is not the rigid expression of the rule. To make it so it would be necessary to say "where health as well as life cannot be saved without it." For there are cases where the *life*, but not the *health* can be preserved without amputation. Suppose, for example, the consequence of a local injury treated without amputation to be a frequent disturbance of the patient's health, interfering materially with his well-being, but insufficient to put life in danger: it does not always follow that this treatment is right or justifiable. It follows on the contrary that if restoration to perfect health would have been the consequence of the removal of the limb by amputation, the treatment with the operation might possibly be the proper treatment.

A man came to the Hôtel Dieu who had lost his right abdominal limb below the knee, from mortification produced, he said, by the use of bad bread containing ergoted rye. His object was to know if anything could be done to better the condition of the stump, the soft parts of which were constantly ulcerating, in consequence of the bones being prominent. The inconvenience was such that he could not make use of his limb for walking, and the cicatrix pressed upon by the bones was so painful as greatly to impair his general health. Now, let it be asked whether, at the time of the mortification, the proper treatment would not have been the removal of the limb by amputation, so as to leave a good, useful, and painless stump. This conclusion seems inevitable. On the one hand, the process necessary for the separation of the dead parts, (of itself probably more or less dangerous to life,) entailed upon the patient a source of constant suffering and great deformity. On the other hand, amputation, perhaps not equally, but we will say equally dangerous to life, would probably have secured a healthy, useful stump. There can be no doubt then that the treatment by amputation would have been the proper one; and yet the treatment without it is that suggested by the rule given by authors; namely, that amputation is to be performed only in cases where the patient's life cannot be saved without it. We do not mean it to be implied that surgeons often act thus, but still, we deem it important as far as possible, to supplant whatever precepts are indefinite and incomplete by positive and fixed rules. In a case like the above, the choice between the two modes of treatment must rest mainly upon their comparative danger. If the probabilities of danger are greater on the side of amputation, so much so as to outweigh the probable inconvenience or occasional disturbance of health entailed by the preservation of the limb, unquestionably it ought not to be adopted; but if the probable danger is about equal under both plans of treatment, the operation ought to be performed. The superiority of one plan over the other is just in proportion to the less degree of danger it offers to life and *health*, and not to *life* alone. The proper rule of proceeding, then, in all cases, may be clearly expressed in a very few words, and in its simplest form, would stand thus:—Place the danger to life and health from the lesion treated by amputation in one scale, and in the other, the danger to life and health from the lesion treated without amputation, and let the decision be made in favour of that plan of which the danger to life and health is decidedly outweighed. Where the two plans are equally balanced, and in cases of doubt, the decision should be in favour of that which causes the less pain, and leaves the body the more perfect in form, or with the less deformity or curtailment.

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[1] Neither Velpeau, Blandin, nor even Cloquet seem to have conceived, or certainly to have expressed correctly the rule which ought to be laid down. Sanson comes nearer to it in saying,—"Amputation ought to be performed only when the danger to which it exposes the patient is less than that of the disease." But to be correct, he should have said, "Amputation ought to be performed when the danger and inconvenience to which it exposes the patient are less than those of the disease treated otherwise."

In cases of doubt, the surgeon will, therefore, abstain from using the knife. As we have dwelt a good deal upon the severity of the loss of a limb, with a view to impress the practitioner with the nature of the weighty duty he has to perform, when called upon to decide whether amputation is proper or not; and in order that he may give the subject his utmost attention, we are bound also to remark, that he must not allow his judgment to be influenced by considerations arising from a mistaken notion of what humanity dictates, and which are sometimes pressed by others. What is right is humane, in this as in most other cases. It is humane to amputate, and inhuman not to amputate where the necessity is pointed out by the rule we have supported, just as much as it would be inhuman to amputate, and humane not to amputate whenever the rule does not prescribe the operation. It is not in treating of this operation that we need defend the profession against the imputation, sometimes attempted to be cast upon it, of allowing the fondness for operating to influence its decisions. The amputation of a limb is always a painful duty to the surgeon. In some operations it is not so: in removing a tumour dangerous to life, he may, indeed, execute the task with a feeling of satisfaction; for he knows that he is extirpating morbid matter, that he is dislodging an enemy. But when amputating a limb, he feels that he is taking away an integral part of the body, which cannot be replaced, for the uses of which there is no substitute, and for the loss of which there can be no compensation.

It is, perhaps, true, that amputation is generally considered the most wonderful of all operations. The notion that prevails in the minds of the uninformed, of the parts entering into the composition of a limb, cannot be so very vague, since we hear persons every day express astonishment that it should be in the power of man to remove the limb of his fellow with knife and saw, stopping the streams of blood that burst from the wound, and so facilitating and hastening its cure that the rest of the body is preserved sound, and in a brief space of time scarcely a scar remains to tell that the patient was not born without the curtailed member.

There certainly is no operation which makes the surgeon appear so great; but we trust this will only make him the more cautious never to abuse the masterly privilege, and consent to remove a limb until his duty command it. In every case, after duly weighing all that can conduce to a right opinion, he will retire in close communion with himself and decide to the best of his calmest judgment.

Thanks to the progress of science, the number of cases in which amputation was formerly had recourse to, is constantly diminishing. As our knowledge of disease, and the modes of counteracting it increase, we are enabled to do more and more without the necessity of resorting to this last expedient.

We now come to the enumeration of those diseases and lesions which it is customary to put down as more or less frequently requiring amputation.

They are as follows:—Malignant diseases, such as the various forms of cancer; some tumours not malignant; mortification; caries; certain of the severest forms of necrosis; white swellings; extensive suppuration, with or without ulceration; fractures; dislocations, and wounds.

Malignant diseases.—It is right to perform amputation for these affections, when there are insuperable obstacles to their complete extirpation without it; whether they have their seat in the soft parts, in the bones, or in both. They are, osteo-sarcoma; spina ventosa; the colloid, hydatoid, and encephaloid transformations; the malignant erectile tumour, (fungus hematodes,) and the divers forms of malignant disease in which these or a certain number of them are blended together, with or without other tissues, and which are generally described under the vague terms of cancer and carcinoma. Unfortunately, however, many of these diseases, being not strictly local, but merely part of the effects or manifestations of an alteration of the solids and fluids generally, break out in the stump or in some other part of the body, especially if energetic measures are not adopted simultaneously with the operation to correct the vitiated state of the whole system.

As we can hardly expect to effect this beneficial change when the malady is of long standing; and that in some few instances a disease of this sort, which at a late period shows contamination of the whole frame, is so far local at first, that without some local cause it might never have been concentrated sufficiently in any one part to break out in an active and destructive form, the sooner the operation is performed the greater must be the chance of a cure. In these cases it is always advisable to amputate as far as possible from the seat of the disease, and whenever practicable to leave an articulation between it and the place of operating. Experience has shown that parts are contaminated, in a great measure, in the ratio of their vicinity to the disease; and it is for this reason, as well as on account of the more complete removal of tissues decidedly morbid by amputation of the limb affected, than by excision or extirpation of the parts immediately diseased, that the former has sometimes been successful after the latter had failed.

Tumours not in their nature destructive to life.—Among the diseases sometimes requiring amputation, may be placed certain tumours which cannot otherwise be removed, and which, although not of a malignant character, exercise a dangerous local influence by their volume or position. Such are certain exostoses and fibrous masses, which by their pressure on large vessels impede the circulation, and may sometimes occasion mortification, or which, by irritating and cramping the nerves, become insupportable. Elephantiasis[1] has also been treated by amputation.

Aneurisms that have produced irreparable injury to surrounding parts, or the treatment of which, by ligature, owing to the diseased state of the vessel tied, has been followed by secondary hœmorrhage, come in the same category. Whenever vessels are so injured that the circulation cannot continue in the limb, but may go on in the stump, (which sometimes happens, since diseased arteries will often perform their functions in the middle or upper part of a limb when they cannot at its lower extremity,) amputation is the only resource, and ought to be adopted.

Mortification, or Gangrene[2].—It is deemed advisable to perform amputation in cases of mortification, in order to spare the patient the long and sometimes hazardous process, which Nature requires for the separation of the dead parts, and for the purpose of securing a good and useful stump[3].

With these, we think a third motive ought sometimes to be allowed to have influence, namely, that the operation itself may produce a salutary effect upon the system. Where mortification of the whole, or of the chief constituents of a limb is produced by an external cause, amputation ought always to be performed, unless there be something in the state of the patient to forbid it. It is a question which has often been discussed, whether or not amputation should ever be performed before the mortification has limited itself. In injuries, such as gun-shot wounds, some parts are quite disorganized, and may, therefore, be considered dead, or in a gangrenous state, from the moment of their infliction; others are so far disorganized that the vital processes cannot go on in them, and therefore, they die at the very commencement of the local inflammatory effort which is necessarily consequent on all wounds.

For lesions of this sort,—indeed, for all traumatic and mechanical injuries of this severity, the sooner amputation is performed the better, as there can be no doubt of the advantage of substituting a clean healthy wound and a cicatrizing process for a ragged laceration and sloughing process, at the earliest possible period. To effect this, the great care of the surgeon must be to cut above the disorganized parts, to let the knife and saw fall upon healthy tissues.

When mortification results from an internal cause, the latter may be general, that is, it may result from a disease pervading the principal part of the vascular system, or having its seat in some other leading organ or organs; or that cause may be local, may reside in, and be confined to the vessels of the limb; and it is only in the latter case that amputation is applicable. There is, however, a state in which amputation may be advisable, which I do not find that authors have marked,—that in which the solids and fluids happen to be in a deteriorated condition at the time of the infliction of some local mechanical lesion.

Here the general bad condition of the body may cause mortification after an injury of the limb, which, in a healthy subject, would have escaped it.

Now if the operation in this case were likely to produce a salutary reaction, which I think possible, it would be justifiable to adopt it. In such a case, where it is hoped the operation itself may have a general beneficial influence, it should be performed at the time the patient appears most susceptible of the healthy reaction; and I think that will be early. Waiting for the gangrene to limit itself would be waiting for what could not take place. I admit that the difficulty of distinguishing this state is extreme, but when detected, no time should be lost.

When mortification is the result of internal disease, the operation should not be performed until an inflammatory line in the living parts has marked its limit. In this case, it were useless and cruel to amputate prior to the spontaneous limiting of the gangrene. Perhaps in this case it may be often better to leave the amputation to Nature. It has been stated that when amputation is performed before the mortification has stopped, the stump will become gangrenous, whether the cause of it be external or internal. But is this sound doctrine? Is there any physiological reason why mortification from a cause purely external should make its appearance in healthy parts cut through in the operation? Indeed, one can scarcely see how it should happen. A local injury, as we have stated, causes the death of parts at once, by completely disorganizing them; or it so far disorganizes them that they cannot bear the supervening inflammation, but die in that process which is then said to terminate by gangrene. But mortification from a local cause is not in itself a spreading disease, as Larrey and some others seem to suppose: it is the death of a part from disorganization. When death seizes the surface of the stump, it arises from one of the three following causes: Either from the shock which the whole body received with the local injury, or because it was in a deteriorated condition at the time the injury was inflicted, and remained so at the time of amputation; or because the operation was performed in parts not sound but too much injured to take on or sustain healthy inflammation. This last cause accounts for the difference of opinion existing on this subject, and enables us to explain why Sharpe, Pott, and others, who had often seen mortification lay hold of the stump, insisted that the operation should be deferred until the mortification was arrested by the formation of an inflammatory circle[1].

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[1] Mr. Crosse lately amputated in a case of elephantiasis, and the result was successful.

[2] These are synonymous terms, and we use them as such.

[3] Sir Astley Cooper thinks that Nature separates the parts so as to leave a good stump.

Caries.—We now know this disease to be an inflammation of the osseous tissue, in the stage of softening or suppuration, and can therefore account for its attacking, in preference, that part of this tissue which is loose and vascular, as we find it in the short and in the extremities of long bones. At a certain stage of caries, the bony tissue is irrecoverably disorganized; and as the consequences of the disease may prey upon the constitution till the life of the patient is exhausted, there are many cases of it which require amputation.

It is the chief and most incurable alteration which takes place in a vast number of those diseases, blended under the indefinite name of white-swelling.

In general, it is only at the very outset of caries that there is any chance of restoring the affected parts to a healthy state; (and except in cases of early efficient treatment, and those in which it terminates by anchylosis before the constitution is irrecoverably impaired,) whenever it is too extensive to allow of the removal of the diseased bone, we have only to choose between amputation and the death of the patient. Amputation is a good remedy for caries when otherwise incurable; because, as experience has proved, the health of those affected, and whose original conformation is mostly the great cause of the disease, often improves after the operation; not only from the removal of the source of mischief, but because the quantum of vital energy as if previously too small for the entire body, becomes sufficient for it after the curtailment of a limb. Certain it is, that the bodies of such persons do often prosper, if they resist the shock and immediate consequences of the operation.

In caries, then, when the bone is decidedly in a softened and suppurative state, beyond the chance of recovery; and when important organs are seriously menaced by the progress of the disease, there should be no hesitation about performing the operation. For the reason we have mentioned, that in this case the lopping off a diseased branch is often of profit to the trunk, as well as on many other accounts, amputation will mostly be found preferable to resection.

Necrosis.—Happily, what we have said of caries does not apply to this disease. It is only the very worst cases of necrosis that require amputation, since by skilful local treatment and good management of the health, if there be adequate strength of constitution, and the periosteum and surrounding parts are sufficiently sound to provide a new bone, the sequestrum will become detached, and may be extracted with safety. But it does sometimes happen, when the disease is very extensive, and situated in the midst of very voluminous and important soft parts, through which the sequestrum cannot be attacked, that the abundance of suppuration would cause death, unless amputation were performed. A patient at the Hôtel Dieu, whose body I examined, died from this cause. The femur, in its three inferior fourths, was reduced to a sequestrum, and shut up in a new bone, out of which nature had endeavoured to let it escape by spontaneous perforations. Unfortunately, these holes were situated in the vicinity of the crural and popliteal vessels. Had they been in the anterior or the outer region of the bone, the nature and extent of the disease might have been correctly ascertained, and the patient's life might have been saved by the extraction of the sequestrum; or had this been found impracticable, by amputation of the limb. The absence of a correct diagnosis as to the precise local circumstances of the disease cost the patient his life.

White swellings.—Diseases of the joints, taken in reasonable time and treated methodically, may generally be cured without amputation, unless the bones have arrived at that state of caries which we have already pointed out as requiring the operation. This happy result belongs more particularly to modern practice, and is to be attributed to our better knowledge of the morbid changes to which the constituent parts of the joints are liable, and of the order in which they occur. At the present day, a vast number of limbs having their joints diseased are spared, which, formerly, would have been amputated. Great credit is due to those practitioners, who, by patient perseverance in the employment of means founded upon pathological knowledge, first obtained a sufficient number of cases to make an impression on the profession, and caused them to pause and employ these measures with that patience, energy, and assiduity which the expectation of a successful issue always inspires, before they resorted to amputation. The delay their employment occasions is by no means dangerous or unfavourable to the success of the operation, which, should it become necessary, will be found less likely to fail after the disease has become very chronic, and made the pulse feeble, than at an earlier period. Indeed, it is the duty of the surgeon to wait and continue to employ such measures, until the patient's general health shows that he would sink under the disease, if the limb were not removed.

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[1] At a time when our pathological knowledge was less perfect than it is at present, mortification was mistaken for a sort of active process, or spreading disease, because in most cases it begins at the extremity of a limb, and gradually extends towards the trunk, and thus seems to spread by a sort of contagion. But this happens because the vital processes diminish gradually in activity, and are carried on with increasing difficulty, from the centre towards the extremities and surface, and that these die first from whatever cause mortification proceeds.

Here it is the state of the body, and not the state of the joint, which determines whether and when amputation is required; for, until the general health gives way, there is always hope of every disease known by the name of white swelling terminating by ankylosis, or in some manner which will admit of the preservation of the limb.

Extensive suppuration, with or without ulceration of the integuments.—Cases of extensive suppuration have been put down among those which may require amputation by some authors. If the patient's life be menaced with exhaustion by the abundance of pus secreted, the surgeon has to consider by what means he can remove the cause of it; and, if this is local, perhaps, in rare instances, all other means having failed, amputation may be indicated. But where the secretion of pus depends, in whole or in part, upon an internal or general cause, it is evident that the operation would be worse than useless.

It is always dangerous suddenly to arrest the suppurating process, and that in proportion to its extent: and, therefore, when a case presents itself in which local suppuration or ulceration has produced so much havoc as to render a limb useless, and put life in peril, no pains must be spared, (for management alone is scarcely sufficient) to ward off the consequences inseparable from the direct stoppage of a copious purulent discharge. The materials of such a drain must be largely, adequately diverted to other external channels, by the most appropriate emunctories, or their reflux internally, which otherwise could hardly fail to take place, must produce congestion in the internal organs, with that tendency to suppuration which makes it almost always fatal.

Fractures[1].—Compound fractures in which the bones are extensively shattered, denuded, and displaced, especially in the immediate vicinity of large joints, in which the main trunks of vessels or nerves are injured, tendons denuded, and the muscular parts largely destroyed or contused; the presence of these complications combined, or the existence of one of them, in a manner to constitute an injury which the careful and analytical investigation we have recommended shows to be irreparable, renders amputation necessary. Terrible compound fractures have often been cured, where the general circumstances were favourable, and sometimes even in hospitals, where the patients were not placed in the purest air, or surrounded by the greatest comforts. Dupuytren saved the leg and life of a gentleman in a case of fracture, in which the posterior tibial artery was opened, by setting the bones, and tying the femoral artery, a bold line of practice, originating, as he thought, with himself, but recommended, I believe, by that excellent surgeon, John Bell.

The following case occurred in hospital practice:—

A strong man, about thirty-five years of age, was brought to the Hôtel Dieu, with one of the severest compound fractures of the leg I ever saw. It occupied the immediate vicinity of the ankle-joint. The ends of the upper fragments protruded through a large wound of the soft parts. The foot with the inferior fragments (which were not more than an inch and a half in length), was bodily displaced an inch, at least, on the outside of its natural position, and seemed to hang to the rest of the limb only by tendons. The patient obstinately refused to submit to amputation, although apprised that it was the only means of saving his life. To add to the gravity of the case, traumatic delirium of the worst kind suddenly came on, during which the patient removed the dressings, and used his limb as if it had been entire, so as to cause the foot to hang still more loosely by the connecting tendons. Yet, strange to say, this man recovered. The delirium subsided. In a few days, a mass of granulations sprung up, as if by enchantment, and wrapping themselves round the ends of the bones, they seemed to draw the foot more and more into its natural position, and thus to achieve that fixation which had in vain been attempted by splints and bandages. The projecting extremities of the fragments studded in coral granulations, which presented a most beautiful appearance, became necrosed and fell off, a firm cicatrix ensued, and the man could walk and use his foot remarkably well.

In cases where nerves and large vessels are uninjured, where the joints and tendons have escaped serious lesion, amputation may not be necessary, unless the destruction of skin and muscle be so considerable as to render the formation of a good cicatrix impossible; or unless the general circumstances in which the patient is placed establish a necessity for the operation.

Splinters of bones can be removed, the ends of fragments can be cut off with a saw; and when a fracture is thus regularised, it is the state of the soft parts only which can make amputation indispensable. We repeat, the general circumstances of each particular case must be taken into consideration. It is probably their omission in the calculation which has rendered the results of various practitioners apparently so opposite; some contending that amputation is hardly ever necessary in compound fractures; others, that it is frequently called for. Among the former, Bardy, and among the latter, Bending, have written in support of these opposite doctrines. Velpeau has recorded some bad cases of compound fracture cured without amputation. Sir A. Cooper's practice abounds with them; indeed, it is to him that we are chiefly indebted for the treatment by which such favourable results have of late been obtained in this department of surgery. Dupuytren's hospital practice was far less favourable in these cases, which I attribute to the frequency with which he was accustomed to renew the dressing, and thereby disturb the limb. It contrasted strongly with that of Sanson, who adopted Sir Astley Cooper's plan of treatment with much success.

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[1] See Pott's remarks on Fractures.

Disunited fractures, whether they have given rise to the formation of an artificial joint or not, may sometimes occasion such serious consequences as to require amputation, when the evil cannot be removed by other measures.

Luxations.—It is only for compound luxations, properly so called, that amputation is sometimes required. But, for these, the operation is more frequently necessary than for compound fractures. Almost always when articular surfaces are largely exposed, the patient's life is in danger, unless amputation be performed without delay, especially if the surrounding parts are much injured.

The danger is greater than in compound fractures, and arises from the number and importance of the organs in which an injured joint excites sympathy—sympathy of the directest and deepest kind; and also from the difficult and peculiar nature of the process required to repair articular structures. The sympathy between the synovial and the serous system is immediate: and the inflammation of all the component parts of joints is not easily borne. Yet there are many cases in which amputation may be dispensed with, viz: those in which the joint is not extensively opened, and the ligaments are but slightly lacerated; and in dislocations of the foot where the injury, although considerable, may be mitigated by the removal of the astragalus. Sir A. Cooper was one of the first to show what nature could effect in these cases, under skilful management, and to him we are indebted for the history of many such lesions treated successfully without amputation[1]. (See ARTHRITIS, TRAUMATIC.)

Wounds.—There are very few ordinary wounds so extensive and severe as to require amputation. When part of a limb is torn off, it will be found better in general to amputate; but, in some instances, the wound is, or may be made sufficiently regular for the formation of a good cicatrix, without the operation. The various and complex lesions, termed gun-shot wounds, very often require amputation: indeed, it is more frequently indispensable for them than for any other mechanical injuries; not only because they may include many of these, such as fractures and dislocations, but because, *ceteris paribus*, they are in the fullest sense of the word, and more strictly than almost any other lesions, contused wounds. The contusion accompanying them is always intense; being carried, for an extent of parts more or less considerable, to complete disorganization, and for some distance, to a degree bordering on disorganization. The tissues are lacerated, and often contain foreign bodies; the bones are frequently splintered and denuded; in a word, the destruction of parts is great, and those not destroyed are irremediably injured, to a greater or less extent. The margins and surface of gun-shot wounds are, by the event, dead. They present, then, at once, mortification—superficial, perhaps, but still mortification combined with more or less of the other mechanical lesions which render amputation necessary. This is the true reason why they more frequently require it than any other injuries, and not because there is any thing burning, venomous, or malignant, deposited in them by the projectiles which inflict them, as was formerly supposed by Ferri and others. A gun-shot bruise or wound, in which the principal substance of the limb is contused to disorganization, and more especially if the nerves and large vessels are injured, (whether or not there be fracture or rupture of the skin,) is decidedly a case for amputation. Another case is that in which the bones are fractured at their articular extremities, except in rare instances, where the wound is small and the bone merely traversed by a ball. In the very great majority of cases where joints are laid open, and the end of one or more bones fractured, death is the result, unless the operation be performed without delay. This appears to be the opinion of the best surgeons, and of Velpeau, whose remarks on this subject are highly valuable.

That gun-shot wounds, in which the bones are comminuted, also require amputation, seems to be an opinion supported by the best authorities: those of the thigh and leg almost always require it[1]. The shattering of the limbs from other causes is not quite so serious, and amputation is not so positively indicated.

Tetanos.—To perform amputation for this disease, (a disease so evidently having its seat in a large portion of the nervous system), when it has once commenced, seems absurd. Strange to say, however, cases are recorded in which it is stated to have been successful. If such a result has really been observed, it can only be explained upon the supposition, that a cure of the disease of the nervous system was effected by a sort of counteraction excited by the operation. That the disease can be cut off with the limb seems impossible. Amputation can be scarcely justifiable here, since a far greater number of cases of tetanos, said to be authentic, have been cured by measures incomparably less severe than that which involves the sacrifice of a limb.

We admit that under unfavourable circumstances, and during the prevalence of tetanos, it may be advisable to have recourse to the operation in those cases of severe injury, for which, under influences less disastrous, its necessity might be doubtful. But this is all that can be admitted. In connexion with tetanos, amputation can hardly be considered in any other light than as a preventive measure.

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[1] See also cures by Langier and Arnal.

[1] In public institutions for the reception of disabled soldiers and sailors, few are found who preserved their lower extremities after these injuries. Such lesions inflicted during the last French revolution, even where every possible care was taken of the wounded—where they were surrounded by the most favourable circumstances, produced death, when not treated by amputation, except in rare instances.

Poisoned wounds.—The bites of rabid or venomous animals are sometimes enumerated as cases that may require amputation. But all that has just been said concerning tetanos applies to these. To cut off a part, after the whole body has become impregnated with poison, is quite out of the question. As a remedial measure, it holds out not the least temptation: the physiological ground for its adoption is slender indeed, and the little experience we have of its effects[1] is quite opposed to it. In such cases, the cause of the wound is a circumstance that weighs in favour of amputation, supposing its gravity in other respects to indicate the operation.

Ankylosis and Deformities.—Amputation has been sometimes performed to rid the patient of a merely troublesome or deformed limb. Where, for instance, its different parts have been thrown into such a position with regard to each other, by ankylosis, as to render it less useful, more troublesome, and more of a deformity than an artificial one would be. Sometimes, indeed, amputation has been adopted mainly for the purpose of removing a part congenitally deformed, or rendered so by disease, and of making the body, in appearance, more symmetrical. Such operations are said to have been performed at the earnest entreaty of the patient, and as it were out of condescension on the part of the surgeon; they are, therefore, aptly enough termed by the French, *amputations de complaisance.* But surely this is a degree of complaisance which nothing can justify. It is to be regretted that surgeons should ever yield to their patients' wishes, to this extent; and we are surprised to find so able a man as Velpeau seriously arguing the point, as if there could be any doubt about it. The only case which admits of doubt is that in which deformity brings on disease, or where the two are combined; and for such a case we have already endeavoured to deduce, from right principles, the rule by which the surgeon's conduct should be guided.

Prognosis.—In speaking of the method by which the surgeon should proceed in order to decide, in each particular case under consideration, whether amputation should or should not be performed, we mentioned the necessity of taking into account all the circumstances relating to it.

We have now to notice those circumstances which, it has been correctly ascertained, do affect the result of all amputations, and the knowledge of which is necessary to enable the surgeon to foresee the probable consequences of the operation he may have to perform; in other words, to establish his prognosis.

With respect to age, it may be said that the younger the subject the greater is the chance of a successful issue; for the restorative power of Nature and her capacity to resist the shock of a severe operation, are greater in the early period of life. In old persons the danger is often very great; their tissues are far from their highest state of elasticity, and the wound is apt to heal tardily. As regards the actual state of the patient's body at the time of the operation, it has been pretty accurately made out, that a habit somewhat reduced is more favourable to success than fulness. In the former, the wound resulting from the operation, and consequently the amount of inflammation necessary for its cicatrization is proportionately small; the parts to be divided being free from turgescence, bear the action of the knife without much local irritation, and are not likely to occasion violent reaction in the system. In the latter condition of body, the wound is large, and the incised parts being voluminous and in full vital energy, feel more acutely, and awaken stronger and more extensive sympathy.

The influence of the mental state may be likened to that exerted by the physical state. When the mind has quickly to determine upon making the sacrifice of a limb, it is done by an effort of some cost to its strength, which incapacitates it more or less to bear the operation; while on the other hand, when a patient has been gradually prepared to expect amputation by a knowledge of its probable necessity, a state of calm resignation, which is highly favourable to success, is often induced. Patient and lasting courage is far more favourable than sudden resolve. The patient, however, must never be kept in a state of suspense when once the operation is decided upon. Mental indifference is decidedly unpropitious, especially when it results from a physical shock produced on the nervous system, as we often see in extensive and violent contusions and gun-shot wounds. The patient who does not care about getting well, most frequently dies. Yielding with fear and reluctance rather than with confidence, is bad. The most favourable mental condition is that in which the patient feels the necessity of the operation so strongly as to consider it his duty to submit to it, and to second by his courage and confidence, the surgeon who has to perform so arduous and trying a task.

Constitutions similar, and in appearance equally good, do not bear so severe a shock as that of amputation with the same impunity. We must consider not only the degree of health in the leading and important organs of the body, but also their pliancy; or, as it may be expressed, their willingness to accommodate themselves to a new state of things suddenly induced, and amounting in most cases to a vast change.

This may be ascertained in some measure by an inquiry into previous circumstances. This want of the power of accommodation is soon evinced by disturbance in the principal functions. If the internal organs be unsound, the disease affecting them becomes active and soon kills the patient, especially when it is of the same nature as that for which amputation has been performed; as we see daily in scrofulous complaints. We cannot often expect a favourable result when amputation is performed for a disease likely to return in the stump, or to break out afresh in some other part. The more distant the place from the trunk, and the smaller the part where amputation is performed, the less serious the operation. Amputation performed on the abdominal is more serious than on the thoracic limbs. The plan of operating and the skill of the operator have also something to do with the result. General circumstances, such as the abode of the patient, the care and comforts he can obtain, the climate, season, &c., bear directly on the prognosis of this as well as of all other important operations.

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[1] Mr. Callaway amputated a limb in a case of hydrophobia without the least benefit to the patient.

Time for Amputating.—Although the time for amputating must in general be a *time of necessity*, yet, as there may be some room for choice in this respect, we admit also, if not absolutely, within certain limits, a time of election.

With regard to mechanical injuries requiring amputation, surgeons of the present day seem pretty well to agree that no time should be lost, and that the operation should be performed immediately after their infliction. Formerly there were opposite opinions on this matter. Some maintained that the operation should be performed, at least, within the twenty-four hours; others that it ought to be deferred until after the decline of the general reaction following local injuries. The Parisian Academy of Surgery decided in favour of the latter opinion, when the question was brought before it, about the year 1760. It was there contended, on the one side, that immediately after the shock of a severe injury, the system is in a state of commotion which incapacitates it for bearing the operation; and that delay has the advantage of showing, in each particular case, Nature's power of reparation, which, when great, may be sufficient to save a limb that would otherwise have been sacrificed, from its appearing at the time of the infliction of the injury absolutely to demand amputation. The opponents of this doctrine, on the contrary, urged the absence of inflammation and suppuration before the local disorder has had time to affect the body and create reaction, as an unanswerable argument in favour of immediate amputation, which, they stated truly, subtracts the patient from the trial to which life is put by the local and general reaction which follows severe mechanical lesions. It is certainly true, that it is better to amputate when the body is in a state of calm, before reaction has commenced; but on the other hand, it cannot be denied, that the operation is in itself a shock added to that of the injury.

If it be true that the body suffers less or runs less risk from this shock than from the inflammatory process and accidents that may supervene when the limb is allowed to remain, then clearly the operation may be performed. Experience shows this to be the case. Consecutive, compared to immediate amputation, has been more than doubly fatal; and the few limbs which have been saved by delay are but a poor set-off against the loss of life it has occasioned.

As we have shown in another place, amputation performed during the process of suppuration but rarely succeeds. When the immediate shock of the lesion upon the nervous system is so great as to cause general stupor for any length of time, immediate amputation is nearly always fatal. But, in such a case, does not the patient perish rather from the primary injury solely; and does not death ensue as certainly where the operation has been omitted? If so, it would perhaps be better to amputate, even in this case, because the operation might possibly tend to rouse the patient, and to create a salutary reaction. Notwithstanding the reluctance a surgeon must feel to amputate when the body remains in a state of stupor which affords little or no hope of success, it would certainly be right to perform the operation, if the severity of the injury were so great as to preclude all possibility of saving the limb.

From what has been stated of other disorders requiring amputation, under their respective heads, an inference may be made, with regard to them, as to the precise time the operation ought to be performed. We shall, however, briefly recall, in this place, the rules which have been recommended.

In most cases of mortification, the formation of an inflammatory circle indicates the time for operating; but the exceptions to this rule, which have already been stated, must not be forgotten.

For all malignant diseases, amputation should be performed the moment the complete extirpation of the malady is ascertained to be impossible.

In the few instances of extensive suppuration, or ulceration, for which amputation is justifiable, the time must vary according to the circumstances of each particular case. M. Blandin[1] endeavours to establish a division of suppuration into acute and chronic.—The terms are not strictly appropriate; because all the distinction that can be admitted is that between suppuration of long standing, and suppuration from a recent lesion. He would call chronic that suppuration which results from scrofulous inflammation in the lymphatic glands, and acute that which occurs to separate the eschar of an extensive burn. The period for amputating in cases of extensive suppuration of long standing is correctly stated, by M. Blandin and others, to be when the patient is somewhat, but not too much weakened by the purulent secretion: in cases of recent suppuration, on the contrary, the operation should be performed as soon as it is ascertained to be necessary. For those cases requiring amputation, in which the surgeon has some choice as to the precise period of performing it, and is not strictly tied to time, he should follow the rules laid down for the performance of operations generally: these he ought the more strictly to adhere to, as among what may be termed the major operations of surgery, there is not one of greater consequence than amputation.

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[1] Dict. de Méd. et Chir. Prat., Art. Amputation.

He must not forget that a mild temperature and settled weather are decidedly favourable to success. He ought also to bear in mind that it is better to operate in the morning than at any other part of the day. The morning is the more necessary as the immediate preparations for the operation require some time; and the accidents which may supervene after it (which often require considerable time also) are much better counteracted during the day than in the evening.

Place at which Amputation is to be performed.—There is scarcely any part of any limb at which the operation may not be performed; but it cannot be performed at each and every part with equal advantage.

It is usually practised in the continuity of the limb, that is, by cutting through the bones; but sometimes it is performed at the joints. Whether the latter should ever be the place for amputating, except in cases where it cannot possibly be avoided, is a question, which, being somewhat new, we shall deem it our duty presently to raise and discuss. That this is almost a new question, will appear evident when it is considered that, up to this day, authors make the difference, as to place, the ground of a natural division of amputations into those which are performed in the continuous and those which are performed in the contiguous parts of the bones of the limbs, a division upon which we must therefore offer a few words. We consider this arrangement inferior to our own, inasmuch as the different methods of operating are more or less, although not equally, applicable to the contiguity and the continuity of the limbs. The division we adopt is quite as simple, and admits of a more methodical classification, without requiring, as the other does, that we should go over the same limb, in describing the amputations applicable to it, more than once.

In the arrangement we adopt, the different methods of amputating may be said to constitute classes,—the different parts of each limb, at which amputation, by these methods, may be performed, species,—and the different modifications of these methods at any part, genera. For instance, in describing the amputations performed on the thoracic limb, we have only to apply the different methods and their modifications to its several parts, the arm, elbow, fore-arm, wrist, and fingers. Thus, everything is clear, and there can be no omission. Whereas, by the other classification, there is some confusion, and the necessity of going over the ground twice is unavoidable; because it is required to treat of the amputations of the limbs by the different methods and their modifications, first, in the different regions of their continuity, and then to return and treat of them, in like manner, in the different regions of their contiguity, or at their several joints.

But we may ask,, ought amputation ever to be performed at the joints, when there is any other part of the limb at which it can be performed? We think not; and we believe this decision, which we rest upon surgical and physiological grounds, to be justified by experience. The danger of cutting into a joint, of exposing an articular surface, has been universally admitted since the time of Hippocrates. Wounds of the joints are dangerous, chiefly on account of the severe sympathetic derangement they may occasion: there is a much greater variety of parts at the joints than in other regions of the limbs; and the sympathy they excite seems to be in proportion to the number and importance of these parts.

The synovial system, taken as a whole, has its different parts all over the body closely united by sympathy. The same may be said of the fibrous system, of which so great a portion enters into the composition of every joint. The sympathy between the synovial and the serous systems is so direct, that an injury of the one will often occasion disturbance in the other. Perhaps these considerations alone ought to be sufficient to deter the surgeon from amputating at the joints. Fractures and other mechanical injuries of the limbs are, to a great extent, dangerous in the ratio of their vicinity to joints, and the more so in proportion to their volume and importance. Wounds which would otherwise be of no great consequence are serious and dangerous, when they affect or penetrate into an articulation. It does, therefore, seem inconsistent for surgeons to operate upon them, when not absolutely obliged to do so.

Surgically considered, these operations at the joints are bad. This is shown by the changes which occur in the stump after the operation, and which we shall have to notice hereafter. Bones, being larger at their articular surfaces than at any other part, require there a proportionately larger extent of soft parts to cover them; whereas, with one or two exceptions, the soft parts surrounding joints are not only less abundant, but they are also the least fit for the purpose. Synovial membrane, tendons and their sheaths, fasciæ and ligaments abound at the joints; and these are ill suited to form a stump, or to cicatrize speedily. The inconvenience of their inflammation is excessive: it may give rise to the formation of pus along the sheaths of the tendons, or in the synovial surface of the joint, which, if left, will often suppurate in dangerous profusion rather than unite to the enveloping parts. The surgeon who has witnessed these local disorders, with tendons, ligaments and aponeuroses isolated, and sometimes dangling about the stump, must ever feel reluctant to amputate at the joints.

If, then, it be true, that this local inconvenience is not unfrequent after amputations at the joints; that they sometimes produce a shock on the system which may of itself be fatal; that they almost always excite a more severe sympathetic derangement in the whole body, and kindle a more intense and more malignant fever than those performed in the continuity of the limbs, ought they not to be limited to such cases as admit of no other resource?

Where, from the extent of disease, the section of the limb must be made either at a joint, or beyond it on the side of the trunk, and where the inconvenience of going beyond it would more than counterbalance that of an articular amputation, the latter must be performed. The same may be said of those cases, in which a limb is so shattered or diseased that it must be removed at the joint immediately connecting it with the body.

One of the most recent attempts to defend articular amputations is that of our respected colleague, Mons. Blandin. He even goes so far as to maintain that they are preferable to those performed in the continuity of the limb. In addition to the preceding observations, a slight examination of his reasons for this preference will be sufficient to show they are not well founded. The advantages he supposes to belong to these amputations may be summed up as follows. He states that they admit of the operation being performed at a greater distance from the trunk; that the parts to be divided are tendinous and not fleshy; that the bone presents on the end of the stump a large surface, the union of which with the soft parts is facilitated by its great vascularity, by the absorption of its cartilage, and by the state of integrity in which it is left; whilst a bone that is sawn through has its vessels injured by the section, and therefore becomes less suited to form part of the cicatrix, and its veins more exposed to inflammation.

We will not deny that joints do sometimes admit of the operation being performed at a greater distance from the trunk; and we have already mentioned that this consideration must be taken into the account. In particular instances, this may render them advantageous; but, as a general rule or abstract principle, the preservation of a few inches of the limb is but a poor compensation for the many disadvantages that beset this species of amputation.

To overthrow the other arguments, we can appeal either to pathological principles or to the results of experience.

First, as to experience. It is an undoubted fact that the great majority of practitioners reject these operations, and operate in the continuity of the limb, because, upon trial, they have found them decidedly disadvantageous. Secondly, as to pathological principles, we repeat, tendons and ligaments are incomparably less suited than muscles to cover and protect the end of a bone in a stump and to enter into the composition of a cicatrix: the vital phenomena of the tissues composing an articulation are more slow and occult and less under our control. These tissues are hard, and of a form and texture the least adapted to constitute a cushion such as the limb requires; and their wounds are undeniably more serious than those of the muscles.

To have a large mass of bone at the end of the stump might be advantageous, if a large and unyielding surface were required there; but everybody knows that the pressure which the stump has to bear should be distributed, to as great an extent as possible, on the sides of the limb. No artificial limb is constructed so as to press on the end of the bone; and if it were, the skin squeezed between the bone and artificial member would soon ulcerate.

M. Blandin truly states that the articular ends of bones are their more vascular parts; and if very active vital phenomena were required in the stump, they would be the best suited to form it. But the contrary is the fact. The stump should be, as much as possible, an inert, elastic cushion, not a highly vascular bony extremity.

From being more vascular, these ends are more susceptible than other parts of morbid action and more exposed to its being excited in them, under the new circumstances in which bone is placed after an amputation. We are quite at a loss to know how our author, after remarking on their vascularity, can go on to say, that any other part of the bone is more liable than they to have its veins become the seat of inflammation, because it is cut through with the saw. Inflammation in the veins of a bone, arising merely from the latter having been cut through, in its dense, unvascular, compact substance, is a thing quite unheard of. On the one hand, then, great vascularity in the bone is not required for the formation and uses of a good stump, or to cause it to heal quickly; and on the other, it tends to make it more susceptible of morbid action.

M. Blandin remarks that the cicatrization of the stump is facilitated by the absorption of the cartilage. But does he not hereby imply that the presence of this cartilage is an obstacle to it. If the process of absorption be necessary, and necessary it is, before cicatrization can take place, the latter must be thereby proportionately retarded. We are told, in the same breath, that these amputations are desirable, inasmuch as the vascularity of the articular end of the bone causes the wound to heal speedily, and yet, that before the wound can heal the cartilage must be absorbed. That the greater vascularity of the bone does not at all compensate for the time required for the absorption of the cartilage, (which is a long process) no one can doubt. If, therefore, he wishes for a prompt cicatrization of the wound the argument tells against him.

We maintain, and it is the doctrine both of sound pathology and of experience, that the end of a bone sawed off, in its compact tissue, is advantageous in the stump, precisely because it is small and can be easily covered in, cushioned and protected by soft parts; because it is not vascular enough to be much exposed to morbid action, yet sufficiently so for all the purposes required of it; and because, from having no cartilage to be absorbed prior to cicatrization, it heals promptly.

M. Blandin would have a stump composed of a large substance of bone and a small substance of soft parts; but it has ever been the object, and it has become the precept of the best modern surgeons to make it of much soft parts and little bone; and we know of no facts or arguments calculated to reverse this maxim.

Setting apart the considerations we have just presented with respect to the joints, the place for amputating is to be determined by the nature and extent of the disease requiring the operation, and the state in which the limb and stump will be left after it. It sometimes happens that amputation may be performed at one of several places, and that the case admits of a choice in this respect. Any point thus selected as the best is called, by the French, the place of election *(lieu d'élection)*. Sometimes there is only one spot at which the operation can be performed at all, or can be performed without serious inconvenience; and when such is the case, the French call it the place of necessity *(lieu de nécessité)*. No very absolute rules can be laid down for fixing the place of election, as that must vary somewhat in each particular case. Still the following general maxims should be kept in view. First,—it should always be, if possible, beyond the disease, and in sound parts. This rule must be rigidly adhered to in cases of malignant disease; but it may be departed from where the inconvenience of operating beyond the disease more than counterbalances that of cutting amidst parts not quite sound, as it happens in some cases where the latter are only the seat of inflammation: experience has shown that parts affected with inflammation and even in a hardened and thickened state are not incompatible with the formation of a good stump. In some cases of mortification, where, from the refusal of the patient or some other cause, amputation cannot be performed in the living parts, it may be judicious to remove the whole, or nearly the whole of the sphacelated portion of the limb, in order to remove as much as possible the inconvenience arising from a mass of animal matter in a state of decomposition.

Secondly,—the place of election should be as far as possible from the trunk. The wound will thus be reduced to its minimum of extent, and, in general, of its danger; and in most cases, the greatest usefulness that can belong to a portion of the limb or stump will be secured to the patient. The exceptions to this rule will be indicated more especially in the description of each particular amputation.

Thirdly,—let the place of election never be an articulation. For the reasons already given, let amputation be performed, if possible, always beyond an articulation rather than in it. Combining these rules with the circumstances of each particular case, the surgeon will always be able to decide at what place the operation is to be performed. The place of necessity varies for different diseases. In cases of mortification it is on a level with the inflammatory circle limiting it, or a few lines only beyond this circle. In malignant diseases it is as near the trunk as possible, or, at any rate, beyond the joint interposed between the trunk and the disease. For mechanical lesions, such as compound fractures and dislocations, it is not necessarily in or beyond the joint situated above the disorder, as stated by M. Blandin, but, on the contrary, in the nearest part to the lesion that will admit of the formation of a good stump. In determining the exact extent of any disorder the surgeon must not content himself with a superficial examination; he must not only direct his attention to the state of the skin but also to that of every other element of the limb; otherwise the knife might fall on parts in a state so different to that in which he expected to find them as to require a fresh amputation.

Preparation of the patient.—By discreet and skilful measures, the patient may be influenced favourably, or somewhat prepared, both in body and mind, to bear surgical operations; and for one so severe as amputation they are especially necessary. The patient must fully make up his mind to bear the operation with firmness and courage. The surgeon can assist him to do this by judicious management. To a certain extent, they should consider together the necessity of the operation; and from a proper and unstudied interchange of thought there will arise a mutual confidence which is highly propitious. This obtained, he must enter into the patient's feelings, reply candidly and attentively to all his inquiries; and, by proving the absolute necessity of the operation, by showing that the pain of it although considerable is not intolerable or of long duration, and by fairly stating the circumstances that will lighten and somewhat compensate for the loss of the limb, set all doubts and fears at rest. In general it is not well to urge the patient to submit to it, but it may be proper to recall to his mind the principal circumstances of the case, such as—the means employed without benefit, the inefficiency of any other measure, the disadvantages of further delay—and then to appeal to him for his own opinion whether he does not consider it necessary. It is not easy to give directions in this matter: a great deal must be left to the sagacity of the surgeon, who will adapt his arguments to the state of mind of the patient. There should be as little delay as possible after the patient has made up his mind. The apprehension of the operation must not be allowed to prey on him. He must not be kept in suspense. A good surgeon will therefore take care that any preparatory treatment which requires time, such as the placing of a seton or blister, be believed by the patient to be intended to act against the disease requiring amputation, and not to prepare him for the operation.

The body should be prepared by the best measures time and the circumstances of the case admit of; they should be such as are most likely to establish and preserve a good and calm state of the principal functions. In general the quantity of food should be diminished a good deal, but not changed to the extent recommended by the French, who go too far in this repect, while the English perhaps do not go far enough. There is a just medium to be observed. More is certainly to be feared from too much fulness, improperly called strength, than from too much emptiness. The digestive organs should have something to do, but their work ought to be light: the food should be simple, easy of digestion, and of a nature to procure a motion once in twenty-four hours. The circulating system should not be too full; but as some blood must be lost during the operation, and as the quantity can be increased by allowing the small vessels to bleed for a certain time before the ligatures are applied, preparatory blood-letting is seldom or never necessary. Besides, it might not be always safe, as the precise quantity of blood lost during the operation cannot always be foreseen or regulated, although we believe surgeons might regulate it better than they do, if they attended more to this matter, which, at present, they neglect to an unjustifiable degree.

As to the more immediate preparations, it is requisite to see that the bowels act within at least eight or ten hours of the time for operating. Should they not act naturally, it will be proper to procure a motion by an enema. We do not think the habit of purging patients, prior to great operations, a good one: surely it cannot be right to throw important organs into a state of commotion at such a time. No food should be put upon the stomach within three or four hours of the time fixed for the operation. According to the state and temperament of the patient, either some, mild, agreeable antispasmodic or stimulant may be administered. It was formerly recommended to employ means with a view to render the patient less susceptible of pain. Guy de Chauliac and his contemporaries gave opium internally, and to a certain extent it is still employed by some modern surgeons. Theodorus proposed subjecting the olfactory nerves to the influence of narcotics, by allowing the patient to smell of a sponge steeped in a solution of opium or henbane; and it has been recently pretended that it is advantageous for the patient to inspire some narcotic gas. These measures are all either useless or pernicious. The plan of tying a strap tightly round the limb, above the place of amputating, is perhaps less injurious and has decidedly some effect; but the pressure is equally efficient, and can be made much better and without the inconvenience of arresting the venous circulation and interfering with the muscular contraction, by the hands of assistants.

It is proper to select a room and a bed or table prior to the operation. A room adjoining that in which the patient is to sleep should be preferred; as it is not desirable he should have to be carried far, or that his sleeping-room should be encumbered with the divers preparations necessary for the operation. It ought to have a good light, opposite to which the patient can be placed; there should be at hand cold water, wine, vinegar, and sal volatile. A bed, or table covered with a mattrass, blankets, and sheets, is used for amputations performed on the abdominal limbs, and sometimes for those of the thoracic limbs. It should be firm, of a convenient height, and not more than three feet wide, so that the patient may be closely approached on either side.

Apparatus necessary for performing amputation and for dressing the stump.—This should always be kept ready in Hospitals; and every surgeon liable to be called upon to amputate without loss of time ought to have it at hand. The instruments necessary for dividing the parts should be placed on one tray, and on another, whatever is necessary for tying the vessels and dressing the stump; or, if both sets of objects are placed on the same tray, it should have a partition to separate one from the other. They should be covered over with a napkin or a piece of linen or cloth, that the patient, on whom their appearance might make a disagreeable or untoward impression, may not see them. And the surgeon or dresser who has to lay them out should recollect the precise number of them, because he can then, in a few moments, (the time necessary for counting them,) ascertain if the apparatus is complete. To be the more certain, however, he should not neglect to recapitulate the divers steps of the operation, taking up each instrument in the order in which it is required and putting it down again; the operator ought to do the same immediately before he begins the amputation, in order to guard against any omission, which might be of serious consequence. Dupuytren never neglected these precautions. The instruments which should be laid out for amputating may be enumerated as follows: 1. A tourniquet, although many surgeons dispense with it and with any similar instrument, substituting for it pressure made by the hand of an assistant. 2. Two or three amputating knives and catlings of various dimensions. 3. Two straight-edged bistouries or small knives, one pointed, and one blunt-edged, and one convex edged knife. 4. A retractor. 5. Two saws, one large with two or three extra blades; the other small and fine enough to cut off a small splinter of bone. 6. A pair of bone nippers. The most convenient amputating knives are those recommended by Lassus and adopted by Velpeau:

they are slightly convex on the edge, and having neither a prominent heel, nor too thin nor too blunt a point, will cut safely from one end to the other; the handle should be sufficiently large to afford the hand a firm and easy grasp. The knives used by the old surgeons, and more especially the curved ones recommended by Wiseman, are unworthy of notice except as objects of curiosity. The bistouries should have fixed handles, or at least such as do not admit accidental motion. The best amputating saw is that invented by Dr. Fox of Derby. Its back is joined to the blade only at the extremities, and being moveable, may be inclined on either side so as to admit of the instrument being worked at the bottom of a hollow wound without the least chafing on the muscles or retractor. By this most useful improvement, Dr. Fox has rendered an important service to surgery. The next best saw to that of Dr. Fox is a common sash-saw rather widely set. Indeed, the surgeon should never use one that is not set sufficiently to work freely, or one that he is not accustomed to use. Every saw is an instrument with which a particular acquaintance is desirable on the part of the person who makes use of it. A joiner cannot work well if he has not his own favourite saw: how then can a surgeon expect to do so? Retractors of various kinds, and made of different materials, have been recommended. Some are made of leather. Baron Percy constructed one of metal which consists of two hemispherical plates, notched at the centre of the corresponding edges for the bone to pass through, and joined together by a hinge. But a large linen compress split for half its length, into one or two straps, according as the part to be amputated may have one or two bones, makes the best retractor, and is the only one now in use.

For tying the arteries and dressing the stump, there should be ready,—1. A good dissecting forceps, a tenaculum, a hook forceps, and two or three curved needles furnished with ligatures of different sizes. 2. Two or three fine sponges and warm water. 3. Straps of adhesive plaster, and a vessel containing boiling water, against the sides of which they may be warmed. 4. Two or more small pieces of linen in which to enclose the ends of the ligatures. 5. Lint, linen compresses, and two roller bandages, each two or three yards in length. The greased strips of linen, with which the French encircle the wound after the straps have been applied, and perhaps the lint used to form a pad to it, may be dispensed with, unless the latter be employed to keep the stump at a proper temperature; but for this purpose flannel or down is preferable.

The ligatures employed should be round, strong, and made of twine waxed, or of silk. They should vary in size, but it is desirable to have them of the least volume which will admit of their being drawn sufficiently tight. Silk ones therefore seem to be the best. The largest trunks of the limbs require only strong dentists' silk. Where an artery is unsound, however, I would recommend a large round twine ligature.

The large flat ligatures used by the French are objectionable: they do not grasp the artery well; nor are they so well adapted as round ones to cut regularly through its internal and middle coat: they occasion suppuration in proportion to their size, and the large knot may prevent their coming away properly.

The straps of adhesive plaster should be from eight to ten or twelve inches long, and from three quarters of an inch to an inch and a half wide. They ought to be of recent preparation that they may stick easily. It is important to attend minutely to what is necessary for the dressing, in order that the patient may be put to bed without loss of time.

The number of assistants required for the operation varies according to the part to be amputated: one will be necessary to manage the circulation in the limb; another will be required to draw up the skin and grasp the limb above the place of amputating; a third should hold that part of the limb which is to be removed; and it will be well to have a fourth to hand the instruments to the operator, to apply the ligatures, and to hand up what is necessary for the dressing.

Measures necessary to prevent and regulate the loss of blood during Amputation.—During amputations performed nearer to the trunk than to the fingers or toes, the divided arteries in most cases would bleed enough to cause serious detriment to the patient, or even death, unless the flow of blood in them were considerably diminished. Perhaps it would be advisable, in many cases, to arrest the circulation in them completely; but this is not practicable. There must be some loss of blood from the arteries; but we have the means of rendering it compatible with the safety of the patient. Of these means, the ancients, generally speaking, had so inadequate a knowledge, that in the few amputations they dared to perform on living parts, the patient seems, according to Celsus and other writers, to have been in great danger of bleeding to death[1]. Peyrilhe, however, gave it as his opinion, that Archigenes was not only acquainted with the plan of guarding against too much bleeding during amputation, by tying a belt or bandage tightly round the limb which he wetted at the same time with cold water, but that he employed a ligature which he passed through the limb and tied so as to embrace, at once, its principal vascular trunks and the soft parts surrounding and covering them, before he began the operation.

Physiology teaches what ought to be done. The object to be attained is to prevent the arrival of more blood in the limb by the arteries than ought to be lost during the operation, without impeding the return by the veins, of that circulating in it at the time. This cannot be accomplished absolutely; because even the best means of preventing the arrival of blood by the arteries, impede more or less its return by the veins; but it can be accomplished to the degree necessary, and often so completely that the patient loses only a part of that blood which happens to be circulating in the limb at the time of the operation. The object can be best effected by pressure made with the fingers. Two or three fingers constitute a small instrument, which (as we have often heard Dupuytren exultingly say) possesses the immense superiority over all unliving instruments, of being endowed with the faculty of feeling, and which, therefore, can single out the principal artery of a limb, and press its tunics together so as to occlude its canal, without exercising much compression even on any venous vessel that may accompany it.

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[1] The expression of Celsus is, "Nam sæpe in ipso opere, vel profusione sanguinis, vel animæ defectione moriuntur."

The command of the circulation with the hand can only be intrusted to an assistant who understands it, and on whom the surgeon may depend. This assistant must place himself by the side of the operator, quite at his ease, and stand as if leisurely feeling the pulse of the artery at the part where it is to be compressed, ready to stop the circulation in it at a moment's notice. He should have examined the patient at some convenient opportunity prior to the operation, and ascertained the precise state and relative situation of the vessel on which he has to act, as well as the degree of pressure requisite to prevent the passage of blood through it.

Just at the instant the incision is about to be commenced, he is to compress the vessel to this degree; and in answer to the interrogatory look or word of the operator, to intimate that he has the circulation in the limb at his command. The pressure should be equal, and made perpendicularly to the plane on which the artery rests, but rather from than towards any accompanying vein. The hand exercising it should be in the most easy position, and so placed that the ends of the finger fall plump upon the vessel.

It will tire too soon if held in a cramped or uneasy position, or if too much force be employed. When the assistant feels fatigue, he can change hands without letting the artery escape, by sliding one down close upon the other. With these precautions, pressure may be kept up for hours[1]. An experienced assistant can exercise pressure for a very long time without fatigue, because he uses only the necessary degree of force, and takes care to hold himself and his hand in an easy posture. This is the plan of preventing hæmorrhage during amputation which is usually employed in the French hospitals, and which some English surgeons adopt[1].

Those who have never seen it tried will be agreeably surprised to find with what ease and certainty the passage of the blood may be completely stopped in a large artery by the fingers properly applied, provided the vessel rest upon something solid, as the femoral artery does on the os pubis, and the brachial artery on the upper third of the humerus. The great requisites are, to place the fingers directly over it, as when we feel the pulse at the wrist, to make the pressure perpendicularly to the resting-place, and to use a regular, and only the necessary degree of force. Much less force is necessary than would be supposed, *à priori*, as any person may discover by trying the experiment on a large artery in his own body, an experiment which teaches better than anything else how to enact the process.

It has been urged as an objection to this plan, that the artery is apt to escape from under the fingers; but if this happens, the fingers can follow it; and in this, we repeat, lies the paramount advantage of compressing with them, rather than with a pad of any kind; as we feel what we are doing, and can regulate the place, direction, and degree of pressure, as circumstances may require. It is true this plan cannot be adopted where the artery is not easily felt, or where lymphatic glands or hardened cellular tissue interpose between it and the fingers, or where it has no solid resting-place; nor can it be applied where the arterial distribution is so anormal as to preclude its employment: where, for instance, the limb is supplied by several large arteries, instead of one main trunk, as it happened in a case in which M. Richerand amputated the arm[2]. In all these cases the tourniquet must be used.

The other method, now in use, of suspending the circulation in a limb during amputation, consists in the exercise of pressure with a tourniquet. The principal precautions necessary in using it are, to select the proper part of the limb for its application, to place the pad directly over the region of the artery, to protect this and the opposite region with a linen compress twice or thrice folded, and to exercise only the necessary degree of pressure, which may be ascertained by feeling the arteries below the place of compression. It should be the exclusive care of one assistant to watch the instrument, and to attend to the circulation in the limb, during the operation. The tourniquet ought not to be applied until the surgeon is ready to begin his incisions: he should make it the last thing, so that the moment he has ascertained the instrument to be well fixed, and has confided it to the care of the assistant, he may begin the operation. To cause the blood to stagnate in the limb, as some surgeons do, by applying the tourniquet before they are ready to operate, can be of no use, but, on the contrary, must be injurious.

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[1] In a case where it was necessary to stop the passage of the blood in the femoral artery for several days without impeding its venous circulation or injuring the skin, Dupuytren employed several assistants, who effected the object in this way. They relieved each other in turns every three or four hours.

[1] A short time ago, one of the authors of this article took charge of the circulation in the abdominal limb, during an amputation of the leg, performed at the Derby Hospital by Mr. Wright. As it was the first time the plan had been tried in this institution, it excited considerable attention. The operator and the surgeons present seemed to think it preferable to pressure made with the tourniquet.

[2] Dictionnaire de Médecine.

Prior to the invention of this instrument, the single strap-belt for girding the limb, known, it appears, to Archigenes, and employed by Avicenna, Paré, and the old surgeons, had undergone some improvements of which the tourniquet may be considered the completion.

The French surgeons began their alterations by placing a pad under the belt, in the situation of the artery. To this, which was a decided improvement, Morel added two pieces of stick, which being passed under the belt, each on the opposite side of the limb, served to twist and tighten it. This addition, for the better constricting of the limb, he appears to have made during the siege of Besançon. Then came Petit's tourniquet, of which the one now in use is an improved modification.

Although by the present tourniquet the greatest pressure is made on the seat of the vessel, and on the opposite side of the limb; yet the constriction exercised all around it may interfere somewhat with the retraction of the muscles, and is certainly sufficient to impede the venous circulation, as may be seen after its application by the turgescence of the veins below it. This is an inconvenience not counterbalanced by the effect of the instrument in benumbing the limb, which Petit justly ascribed to it, but which, as we have stated, can be produced as well by the assistant who has to draw up the skin. It is also necessary to employ more force with the tourniquet than when pressure is made with the fingers; because the latter can cover precisely the region of the artery without extending beyond it, which the instrument cannot do.

It is also less advantageous than direct pressure, because it cannot, like the hand, be applied always at the upper part of the limb, out of the way of the operator.

Notwithstanding these disadvantages, which attach more or less to all instruments of the kind, the tourniquet answers the purpose sufficiently well to be employed with safety.

The compressor which Dupuytren has sometimes used for the cure of aneurism, and which consists of a semicircular piece of strong steel, sufficiently large to encircle the limb, with a pad at one end, and a handle moving a second pad at the other, would serve very well to compress an artery during amputation. It has the advantage of limiting the pressure to the opposite sides of the limb corresponding to the pads, but is somewhat objectionable, from being heavy. In case such an instrument as this, or the tourniquet could not be procured, the *garrot* proposed by Morel would be found a tolerably good substitute for them.

Knowing the principles on which the circulation of the limb ought to be regulated for amputation, the surgeon will generally be able to devise means for carrying them into effect under any circumstances. But whenever he has a good assistant, and the limb is supplied by the usual main artery easily felt and compressed on a solid resting-place, and he can therefore choose between direct, or (as it may be called) intelligent pressure exercised with the hand, and the blind compression made with an instrument, he will do well to prefer the former.

GENERAL METHODS OF AMPUTATING.

We shall now describe the plans of amputating which may be called *General Methods.* They are three in number, and are usually termed the Circular Method, the Oblique or Oval Method, and the Flap Amputation.

Circular method of amputating.—As its name indicates, this method consists in the division of the soft parts by a circular incision; that is, an incision made by carrying the knife once or several times completely round the limb, so as to cut them all through, from the skin to the bone. This division may be made by one, two, three, or more sweeps, or complete circular strokes of the knife.

A good amputation is that which is followed by a proper stump; and the knife ought to be applied a sufficient number of times to secure this result.

In dissecting what is considered a good stump, some years after amputation, we find the skin forming its surface united by its deep side to dense cellular tissue, in which are the ends of the muscles, fascia, nerves, and remains of vessels, all blended in one common cicatrix, in which the bone is sunk and imbedded. This cicatrix, which is of very firm structure, constitutes a proper cushion for sustaining whatever shock or friction the stump may be exposed to; and, being elastic, and left projecting beyond the bone, which it protects from all pressure, is admirably adapted to the purpose.

The end of such a stump, at least, for sometime after cicatrization, is decidedly concave, and represents a hollow cone, the sunk apex of which is formed by the bone, and the projecting base by the integuments. The depth of this cone should be such, that all the weight the stump may have to bear shall press on the soft parts only, and not on the end of the bone. This depth may, therefore, vary a little according to the volume and structure of the limb, and the uses required of the stump.

The slightest reference to the anatomy of the limbs shows that a good stump, of this shape, can only be secured by dividing certain layers, more or less definite, in which the soft parts present themselves in the limbs, so as to leave them of different lengths. From the anatomical structure of these layers, the moment they are divided they shorten to different degrees, but all more or less by the effect of their own contractility; so that the surface of the stump is not at the place, taken on the bone, where they are divided, but at the place to which they retract, or at which their cut ends remain after they have retracted. For example: a muscle covering, from its upper end to the place where it is to be divided, twelve inches of bone, will cover much less (say nine or ten) after its division. Inasmuch, then, as the layers shorten to different degrees, and must have different lengths after shortening, (the superficial or cutaneous one requiring to be left long enough to wrap over the cut ends of all the others, as well as the bone) it is absolutely necessary, for the formation of a good stump, to divide them layer by layer, and to make at least as many circular incisions as there are distinct layers[1]. If the different layers were of a nature to retract exactly to the same degree, and required to be of the same length after their retraction, one circular incision would be sufficient to divide them; it would be necessary to wind the knife only once round the limb, and to cut through them all, from the skin to the bone, at one sweep. But as they require to be left of different lengths, and as they are not retractile to the same degree, each layer must be cut through separately.

In determining, then, how the section of the soft parts should be made, we must be guided by the number of layers it is necessary to distinguish in them, by the degree to which each will retract on being divided, and by the length each ought to preserve after retraction.

In general, three layers require to be distinguished: the skin and subcutaneous cellular tissue form one; the muscles, not attached to the bone near the place of amputation, constitute the second; and those which are so attached make the third[2].

The skin with its cellular tissue retracts, of itself, but little; so that the quantity of this membrane required to form the surface of the stump will indicate, pretty nearly, the place at which it should be divided. It ought always to be left rather full than scanty. Perhaps a better general rule cannot be given than to leave it longer than the bone, by half that diameter of the limb to which the line of cicatrix is to be perpendicular. Muscles retract according to the length of their fibres, measured from the place of their attachment to that where they are to be cut through: the greater this length, the more they retract. The first, or superficial layer of muscles being composed of those of the longest fibres, retract much more than the second or deep layer. But as the muscular structure is somewhat different in this respect, in the thoracic and abdominal limbs, and in various parts of the same limb, precise directions can only be given as to the place where the layers should be divided, in the description of each particular amputation. We may premise, however, that the superficial layer must be cut through much farther from the trunk than the deep one, and that the surgeon should always take as a guide the anatomy of the muscles he has to deal with.

If the muscles are left of such length that by closing the wound, those of one side can be easily made to meet those of the other side of the limb, between the end of the bone and the skin, they will be of the proper length for the formation of a good stump; and, although there are many amputations in which this rule cannot be strictly followed, it should always be the aim of the surgeon to adhere to it as closely as possible. The quantity of integuments preserved should vary somewhat according to their state of tonicity; a fourth or fifth less will be required when they are flabby than when firm and elastic. The same remark applies, in some measure, although less strictly, to the muscles.

By whatever incisions the parts are divided, they should be cut through, so that the entire section shall be perpendicular to the longitudinal axis of the limb; otherwise, the weight the stump may have to bear would not be equally distributed, but press unduly on whatever part projected beyond the level.

We shall now describe the different plans that have been proposed for performing amputation by the circular method, beginning with that generally adopted at the present time.

Modern plan.—The plan approved by a great number—probably the great majority—of our contemporaries, is that most in conformity with what has just been stated regarding the order and manner in which the parts should be divided. It may be described as follows:—

When the surgeon has ascertained that all is ready, that the instruments are at hand, that the circulation is well attended to, and that the patient and assistants are properly placed, he should direct one of the latter to grasp the limb with both hands firmly, about a hand's breadth above the place where he intends to make his first incision, and another to support steadily the part about to be removed. Both these assistants, especially the latter, should place themselves in an easy posture, so that they can support the limb steadily during the whole time of the operation. Standing on the right or left of the patient, according to the part to be amputated, the operator should place himself in such an attitude, as to be able to stoop and rise steadily, by bending and extending himself without moving his feet. To perform the operation dexterously, he must not be moving about, or placed in an awkward position. Holding the knife (which is to be handed to him by an assistant) as he would hold a sword[1], and grasping it firmly, he is to pass his hand and arm under the limb, so as to encircle it, and bring the edge of the knife fairly upon its anterior region. Here he begins to cut, and by winding his arm round back again, he brings the edge of the knife with equal and moderate pressure over every point of the circumference of the limb, and divides the skin and cellular tissue down to the fascia, by one complete circular incision, made to terminate exactly where it commenced. In this, and in all incisions made round a limb, the knife must not be depended upon to cut solely by pressure, or by motion in one direction, but by a sawing motion to and fro, communicated to it whenever necessary.

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[1] Alanson's ingenious device for effecting the desired object by one incision is not practicable.

[2] Authors usually employ the terms "superficial" and "deep" to distinguish the two layers of muscles; but these do not give a sufficiently exact notion of what is meant.

Very little pressure is required, or ought to be made on the instrument; the degree necessary should be measured and appreciated by the depth of parts to be divided at the commencement of the incision which on that account is to be begun slowly, and continued cautiously, the eye always preceding and directing the hand. When the entire circle cannot easily be gone over by one incision, it should be completed by a second, made by re-applying the knife, and drawing it in a contrary direction, from the beginning to the termination of the first. Some surgeons always make the circle in this way—by two incisions; because, as they justly affirm, it can be made more easily, more safely, and perhaps more rapidly than by one.

Immediately after the first incision, the skin, with its cellular tissue, is to be drawn up to the necessary extent, by the assistant aided by the operator who is to detach it from the aponeurosis with the end of his knife, or with a large probe-ended bistoury, and if much be required, to turn it back like the end of a sleeve[2].

Half an inch below the place to which the edge or fold of the skin has been drawn, the surgeon is to divide the fascia and all the muscles down to the bone, by an annular incision, made by one or two sweeps of the knife, in the same manner as that for dividing the integuments. This incision, although carried at once through all the muscles, is final only for the superficial layer. It is made through them all, in order to insure, beyond the possibility of escape, the complete and equal division of those constituting this first layer, and which otherwise might not be all cut through; because their thickness cannot be estimated beforehand, with exactness sufficient to indicate the degree of action of the knife necessary to divide them, and them only. It serves to divide, to a positive certainty, all the superficial muscles, and to distinguish them from the deep ones; which last, retracting less, and requiring to be left shorter than the superficial layer, must be divided by another incision. The separation between the two layers is effected at once; for, as soon as the incision is made, the muscles composing the first or superficial one retract, and leave the others, which retract less, projecting beyond them, and forming with the bone the central part of a cone, placed inversely to that which the stump itself ultimately represents.

At the base of this cone, on a level with the retracted ends of the superficial layer of muscles, the operator must again apply the knife, and, by a third circle of incision, divide the deep ones.

With a small knife he is now to detach from the periosteum the fibres immediately surrounding it, conformably to the excellent precept of Celsus: in fact, to dissect up to the extent of an inch, more or less, round the bone, which, when sawn through, will thus have its end covered and protected, even by these, and remain imbedded in them as before the operation. This is a very important part of the operation; for if these fibres or the periosteum are detached further than the section can be made with the saw, the denuded end of the bone must exfoliate and disturb the cure. The retractor must be carefully placed close under these fibres, so that the bone may be sawn through, up to the very highest which has been detached, and not left devoid of muscular attachment even to the extent of a hair's breadth: as thus, and thus only, can we be sure of protecting it from all necrosis, as well as of giving it the disposition which will best conduce to the formation of a good cicatrix. The surgeon is to place the retractor so that the bone lies at the bottom of the slit which divides half its length into two straps. With these straps crossed in front of the bone, and the other half of the retractor placed posteriorly, an assistant is to support the soft parts and protect them from the action of the saw.

To cut through the bone, the surgeon is to place his thumb-nail fixedly on it, close against the retractor, and then adjusting the saw at its heel to his nail, which serves to guide it, to set in, or make a track by drawing it steadily backwards, with scarcely any other pressure than that of its own weight. He continues to saw by moving the instrument held lightly in his hand, perpendicularly to the axis of the limb, to and fro, in strokes always steady and gentle, but becoming more so, and accompanied by less pressure, as he approaches the completion of the section; so that there may be no danger of splintering the bone[1]. During this part of the operation, the assistant, who holds the parts to be removed, should do nothing more than bear the weight of it in his hands, one of which should be placed near the saw. The least motion of the limb would interfere with the action of this instrument, or snap the bone. He must therefore watch the action of the saw, and not look at the operator; for so sure as he does, or is told by him to move the part in any direction, the saw will be nipped, or the bone splintered: so slight a motion will do one or the other, that nothing ought to guide the assistant but his own judgment. Although the necessity of this precaution seems so obvious as hardly to need mention; yet, for want of attention to it, the bone is often splintered. If the saw happened to be nipped, the surgeon would say "lower the part," and the assistant looking at him and not at the saw, obeying the word instead of attending to his own sensations, would indeed lower the part, but snap the bone. If the surgeon interfere at all with the position of the limb, he had much better do it with his hand which has hold of the bone, than by giving any direction to the assistant. When the precautions we have recommended are neglected, and the bone is splintered, the surgeon must remove any irregular projections, or roughness it may present, with a very fine saw, or with a pair of bone-nippers, so as to leave its end perfectly smooth. It has been recommended to ease off the sharp margin of this end by scraping it with a knife or file; but besides that nature does this afterwards much better than art can do it, to scrape the edge of a bone is to denude it, and necessarily to cause it to exfoliate. When the bone is sawn through, and its end on the stump left with a clean smooth surface, the amputation is finished.

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[1] When the knife is held between the fingers and thumb, and not grasped in the hand, the surgeon has not the same, nor even sufficient power over it.

[2] The origin of this practice of turning back the skin is attributed to Alanson.

[1] To use the saw well requires a good deal of practice. Every surgeon should know that the art of sawing does not come of itself, and can only be acquired by practice. We say this the more earnestly, because it is somewhat rare to see an operator use the saw properly. Good joiners seldom or ever splinter the most delicate piece of wood; but surgeons are

Such is the plan of performing the circular amputation generally adopted at the present day. We have now to describe and compare with this plan, and with each other, the other plans of executing it, which surgeons have from time to time proposed.

Plan of Celsus.—The soft parts are to be divided down to the bone, and then dissected off and drawn back, so as to leave some part of it bare. The bone is to be sawn through as near as possible to the sound flesh adhering to it, eased off in front, where the saw may have made it rough, and then to be covered with the skin, of which a sufficient quantity should be preserved, to close it over to the greatest possible extent.

Plan of Wiseman and Paré.—The plan of Wiseman, who appears to have operated in the same manner as Paré had done before him, may be gathered from the following quotations from his work:—

"The member is to be supported by some one, whilst another standeth behind the patient and draweth up the skin and musculous flesh. Then make your ligature two fingers' breadth, or thereabouts, in the same parts.

"This ligature made, the assistant strengthens it whilst he draws up the musculous flesh. In the mean time, the operator, with a sharp crooked knife, by a turn with his hand, cuts the flesh off around the bone; then with the back of it he scrapes the periosteum from the bone; if there be two bones, then, with a dividing knife, he separates the fleshy membrane from them. The bones freed from the periosteum, Guido proposes a linen cloth, and Hildanus a kind of purse, to be brought over the upper divided flesh, to pull it upward and make more way for the saw. But I think that needless. The flesh divided, the parts separate of themselves; besides, the assistant's pulling up the musculous flesh is sufficient. That done, you are at liberty, whether you will cauterize the vessels by a button cautery, or, by ligature, stop the bleeding, or by agglutination."

Plan of Cheselden and Petit.—After stating, that when the parts are flaccid they should be tightened by two ligatures, applied round the limb—one above, the other below the place at which it is intended to amputate, Petit describes his operation in the following manner:—he says, "It has ever been considered an essential point in amputations, to preserve a good deal of soft parts, and to bring them together, in order that the bone may be more speedily covered, and the cure hastened. It was with this view I conceived the plan of cutting them through by two circular incisions. I begin the first an inch below the place where I intend to saw through the bone, and by it divide only the skin and fat down to the aponeurosis. I have the integuments drawn up, so as to uncover, for more than an inch, the muscles beneath them. These I divide by the second incision, and draw them back with a retractor; and thus the bone, after it has been sawn through, is left sunk in the midst of them."

Plan of Benjamin Bell.—The directions given by this excellent surgeon, are, first to divide the skin by one circular incision, and to preserve enough of it to cover the surface of the stump; in the second place, to divide the muscles down to the bone by another incision; and, thirdly, to dissect up round the bone, so as to be able to saw it off considerably above the cut ends of the muscles.

Alanson's Plan.—As there has been considerable difference of opinion with respect to the exact manner in which Alanson operated, we shall give his own description of it. In his Practical Observations on Amputation, page 33, he states, "I shall now bring into one view our established mode of performing the operation of amputation on the thigh, and the after treatment, as practised in the Liverpool Infirmary. Apply the tourniquet as usual, and let an assistant draw up the skin and muscles by firmly grasping the limb with both hands. The operator then makes the circular incision as quick as possible, through the skin and membrana adiposa down to the muscles; he next

constantly splintering bones in the living body. The reason of this difference is obvious; the former have learnt to saw—the latter have not.

separates the cellular and membranous attachments with the edge of the knife, till as much skin is drawn back, as will afterwards cover the surface of the stump with the most perfect ease. The assistant still firmly supporting the parts as before, apply the edge of your knife under the edge of the retracted integuments, and cut obliquely through the muscles, upwards as to the limb, and down to the bone; or, in other words, cut in such a direction as to lay the bone bare, about two or three fingers' breadth higher than is usually done by the common perpendicular incision; and continue to divide or dig out the muscles all round the limb, by guiding the knife in the same direction. The part where the bone is to be laid bare, whether two, three, or four fingers' breadth higher than the edge of the retracted integuments, or, in other words, the quantity of muscular substance to be digged out, in making the double incision, must be regulated by considering the length of the limb and the quantity of skin that has been previously saved by dividing the membranous attachments. The quantity of skin saved, and muscular substance taken out, must be in such exact proportion to each other, as that by a removal of both, the whole surface of the wound will afterwards be easily covered, and the length of the limb not more shortened than is necessary to obtain this end. The bone, being now laid bare all round, is to be divided as usual with the saw, and as high up as possible, which will be more easily executed if the retractor, recommended by Gooch and Bromfield, is first applied for the support and defence of the soft parts."

Plan of Ledran and Louis.—This plan of amputating, as applied to the thigh, is thus described:—You are to begin by making a deep incision, which is to divide at once the skin and muscles, at the distance of three fingers' breadth below the place where it is intended to saw through the bone. This done; the ligature employed to keep back and tighten the skin is to be removed, and the muscles thus liberated, will immediately retract and take new positions. You are to keep back the flesh with a split compress or retractor, and then to divide, with a bistouri, the rectus, the vasti, and the adductors, at their attachment to the linea aspera of the femur. By this method the bone may be divided three fingers' breadth higher than when it is cut through on a level with the muscles bound down by the ligature.

Plan of Dessault.—Although the plan of amputating we have described as being that of the moderns, is claimed by the French, as the invention of Dessault, a doubt may be fairly entertained, whether his operation exactly corresponds to the modern plan. We shall therefore briefly describe it apart. Bichat distinctly states, that Dessault performed the operation "*à trois tems.*"

According to this author, he first divided the skin and had it drawn back by an assistant, whom he aided, by detaching it from the aponeurosis with the point of the knife. He next divided all the muscles down to the bone, opposite the margin of the retracted skin; and thirdly, when those of the superficial layer had retracted, opposite their retracted ends, he cut again through the deep ones, and then sawed through the bone.

Plan of Dupuytren.—The skin being drawn back tight by an assistant, who grasps the limb, the operator is to divide the soft parts down to the bone, by one sweep of the knife. The superficial muscles with the skin will then retract, and leaving the deep ones prominent, give to the stump the shape of a cone having its base towards the body. Upon this base, opposite the ends of the retracted muscles, another circular incision is to be made, to divide a second time those adhering to the bone; and, as long as any of these remain projecting, they are to be divided at the base of the cone they represent, by successive incisions, while the rest of the soft parts are held back by the assistant.

The bone may be thus denuded to the extent of more than six inches. The operator is to dissect round it, and make a track for the saw, (by which he will lay it bare still higher,) and after placing the retractor, to saw it off close to the fibres adhering to it[1].

We shall now offer a few remarks on the comparative advantages and inconveniences of the different plans of performing the circular amputations we have just described, in order to set forth their respective value.

The plan adopted by Paré and Wiseman is generally considered as that of Celsus; but it cannot be considered so good as the latter, because it omits to prescribe the detaching or dissecting off the fibres immediately surrounding the bone. The additional precaution it includes of the application of a ligature round the limb does not compensate for this omission. Petit's plan of amputating,—the first devised after that of Celsus which will bear comparison with his, ensures,—by the double incision, (as the separate division of the integuments and muscles is called), the preservation of a sufficient quantity of skin to form a covering to the stump. This constitutes its distinguishing character and chief excellence, and makes it far superior to the plan of Celsus. But however great and unquestionable this superiority, it is diminished by the omission of the important precept of Celsus, to dissect off the fibres which immediately surround the bone, before it is sawn through. At the same time, it ought to be mentioned, in justice to Petit, that, in speaking of the amputation of the leg, he distinctly directs the fibres attached to the bone in the interosseous space to be dissected off and preserved, although he appears to do so principally that they may form a safe lodgment for the vessels.

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[1] Velpeau has committed an error in attributing to Dupuytren another plan of amputating, which he has described in his Chirurgie Opératoire. From long personal observation, I can affirm that the plan of this celebrated surgeon is the one described as his.

Perhaps he was accustomed to adopt the precept of Celsus in amputating, although it does not appear in the description he gives of this general plan; and we are the more inclined to believe this to have been the case, because the same thing has happened to other authors, with respect to this very precept; deeming it perhaps a matter of course that it would be made, as it ought to be, part of every plan of amputating.

Making the first incision entirely subservient to the division and preservation of the skin was so important an improvement on the plan of Celsus, that it is difficult to believe that he who invented it could overlook the advantage of dissecting up round the bone, so as to preserve for its defence the fibres immediately attached to it. Still it does often happen that the mind achieves an invention without carrying with it the discoveries which had preceded it: and this is much to be regretted; for the plan most likely to effect the object of every one desirous of contributing to the advancement of science, is that he should take all that has been done by his predecessors and contemporaries, and then see if he can add anything valuable of his own. If Petit and Cheselden had included among their precepts that of Celsus, to dissect up round the bone before sawing it through, their plan would have been nearly as good as any that has since been devised.

Benjamin Bell positively adopted this precept, which he combined with the plan of Petit and Cheselden; and thus became the author of a better operation than their's. Bell's plan unites the two essential conditions of a good amputation, the preservation of skin to cover the stump, and the preservation of muscular fibres to protect the end of the bone. It is, therefore, inferior to none, except the modern plan, and to that only in a slight degree.

The object aimed at by Alanson, namely, to preserve sufficient skin to cover the surface of the stump, and to leave the bone sunk and well defended in the muscles, is that sought to be accomplished in the modern plan of amputating, which is decidedly the best; and though he takes the proper measure for attaining it in his mode of dividing and preserving the skin, he falls short of it in the manner in which he directs the section of the muscles to be made. Indeed, it is impossible to follow the direction he gives for dividing the muscles; and if it were possible, their cut ends would not form a hollow cone as he states, at least not for a moment beyond the time of their division; for, the superficial ones would retract so much, that the cone formed would be very irregular, and perhaps inverted, immediately after their retraction.

To allow for this retraction, the section would require such an obliquity, that it cannot be made by one sweep of the knife, unless the instrument is used as a scoop, its point resting on and describing the circumference of the bone, while the part of its blade corresponding to the circumference of the limb describes the latter. To cut through the muscles of a small limb at all obliquely upwards towards the bone is extremely difficult, and to make the section sufficiently oblique, quite impossible by one sweep of the knife, as Alanson proposes.

Upon the whole, the plan of Alanson may be said to be far inferior to that of Bell, and scarcely equal to that of Petit; because, although as regards the division of the skin, he proceeds in the same manner as these authors, his mode of dividing the muscles is not so good as theirs.

The plan of Louis is intended to obviate the unequal retraction of the superficial and deep muscles, by the division of the deep layer by a separate incision after the section and consequent retraction of the superficial one. Unfortunately, however, Louis directed that the latter and the skin should be divided together. This plan differs scarcely at all from that of Celsus. Louis himself remarks, that it is rather the revival of the plan of Celsus than a new one of his own which he recommends; and, in fact, the only difference between the two appears to be, that Louis drew back and tightened the skin by means of a ligature applied round the limb, and divided by his first incision a greater thickness of muscles than Celsus.

We observe in Louis the same unfortunate reluctance we have before noticed in surgeons, to adopt in their own plans what is good in those of their immediate predecessors. Louis not only overlooked the necessity of dividing the skin first, and making sure of a sufficient quantity of it to cover the surface of the stump, but took great pains to show that the preservation of a little too much skin is a great disadvantage.

But experience has demonstrated that the preservation of the skin, as directed by Petit, is of so much importance as to establish at once the great superiority of his method over that of Louis. The merit of Louis, in what concerns amputation, lies in the accuracy of his views with respect to the manner in which the muscles retract and influence the shape of the stump; and if, as there is reason to believe, his views led to the modern mode of dividing the muscles by layers, founded upon the law of their retraction, in order to do him justice, we have only to transfer our praise from the operator to the physiologist. It is also right to notice that Louis admitted the propriety of a separate incision for preserving the skin in amputations of the forearm and leg. It was for the arm, and more especially for the thigh, that he recommended the plan which bears his name.

Dupuytren, by a strange and inexplicable fatality, operated like Louis in dividing the skin and muscles together. He differed from him in making more incisions of the latter, and in having the skin drawn tight and fixed by the hands of an assistant, instead of employing a ligature.

His incisions were made with such velocity, that the eye could scarcely follow them; and to superficial observers, to those who were mere spectators, his amputations appeared splendid. The dexterity of the operator excited their admiration. But in myself, who assisted Dupuytren in these operations, the admiration was mingled with regret. I had to watch and dress the patients, and I could not shut my eyes to the evil results. The stumps were often conical in the wrong sense; sometimes even the bone was salient and afterwards exfoliated. Those who witnessed the operation only, went away with the notion that Dupuytren's amputations were equal to his other operations, almost all of which were excellent. This was unfortunate; for had it been otherwise, the general opinion of the profession would have been against his plan, and he might have been induced to alter it. His great fault lay in not devoting his first incision entirely to the division and preservation of the integuments. This he either did not see, or thought he could counteract by preserving an additional quantity of muscle; for he was aware that his stumps were often faulty; and I have frequently seen him make more than three sections of the muscles, and also dissect up round the bone, whispering as he proceeded, "Surely I shall preserve soft parts enough here!" as if determined to secure a good stump.

He had placed the originality of his plan of amputating, as a modern one, in cutting at once to the bone, as directed by Celsus. He was careful, as I have stated, to adopt the precept of this author to dissect off and preserve the fibres immediately attached to it. So far his operation was exactly that of Celsus. He really differed from him only in dividing the deep muscles over and over again, as long as any of their fibres remained projecting. I never could discover any valid reason why he adhered to so bad a plan of performing amputation. He was, undoubtedly, so much accustomed to perform operations upon plans of his own superior to those of his contemporaries, that to operate as they did was to depart from a long-contracted habit; but it is much to be regretted that he did not imitate them in adopting the modern plan of amputating, which justice obliges us to confess is immeasurably superior to his.

From the foregoing examination, we think no surgeon can hesitate in giving the preference to the modern plan of performing the circular amputation, and a reference to the changes which the parts forming the stump or the remaining part of the limb undergo after amputation must strengthen his conviction of its superiority. It must be evident to every physiologist, that it is the only one which prevents the bone ever being prominent, and ensures the division of the parts, so that the surface of the stump shall represent a hollow cone. The more amputations we see, the more shall we be impressed with this truth. And it is one of so much importance, that we hope our friend M. Velpeau will see reason to reconsider his assertion, that the same result may be obtained by whatever method the circular amputation is performed. It may, perchance, be obtained in some few instances where the limb is small and circumstances are favourable; but whoever would guard against the serious and often irremediable mischief of a sugar-loaf stump, must adhere strictly and carefully to the modern plan. To preserve skin enough to cover fairly the whole surface of the stump without any stretching of this membrane; to divide the muscles layer by layer, so that after retracting, those nearest the skin are left the longest, and those next the bone the shortest, and that there is, as far as possible, a regular slope from the former to the latter; to divide the bone so that no portion in the stump be left uncovered by muscular fibre; such are the great objects to be aimed at in the circular amputation, and which, we repeat, can be accomplished only by the modern plan of operating.

The surgeon, therefore, cannot be too careful in determining at what point the bone ought to be divided before he begins his incision.

The method of amputating by Flap consists in the formation of one or more flaps, out of the soft parts, with a view to the immediate covering of the stump, and the more speedy cicatrization of the wound. Although Sprengel and Gagnier seem to refer the origin of this method to Celsus; and Velpeau considers that it is described with tolerable clearness by Leonides and Heliodorus, it is nevertheless certain, that a plain and satisfactory description of it was first given by an English writer, J. Yonge, at the end of a dissertation, entitled, "*Currus Triumphalis e Terebintho,*" which he published in 1679. Yonge states that this method of amputating originated with N. Lowdham, a surgeon at Oxford, and to him, unquestionably, the honour of this improvement belongs; but it is only proper to observe, that such a proposal must have naturally suggested itself as soon as surgeons began to be aware that the scaling and exfoliation of bone did not of necessity form a preliminary step towards the healing process. Amputation by flap encountered some opposition from Kœnerding, and was only resorted to, at first, in cases of amputation below the knee, and in general only a single flap was formed. Emboldened by success, the surgeons in the following century extended it to the amputation of the fore-arm, and subsequently to that of the arm, and even of the thigh.

In 1696, Verduyn of Amsterdam proposed a modification of it, to which he ascribed advantages, now known to be illusory; he imagined that the compression of the vessels of the flap against the extremity of the bone would suffice to prevent hæmorrhage.

Sabourin, of Geneva, in 1702, addressed a memoir on the subject to the French Academy, without, however, producing any other than a mere momentary impression in its favour.

When its application was extended to the amputation of the thigh by Ravaton and Vermale, the simplicity of the manner in which it used to be performed was effectually destroyed by the former. He described his plan to the French Academy in 1739; his first incision, which he made with a crooked knife, was circular, and went to the bone; he then made two other incisions, perpendicular to the first, one at the fore part, the other at the back part of the limb, avoiding the principal vessels, until the flaps were detached from the bone, to the extent of four fingers' breadth above the first circular incision.

In the flap method the operator forms one or two flaps, seldom more; the incisions being directed from without, inwards, or from within, outwards. In the former, which is Langenbeck's mode, the knife proceeds ascending the limb obliquely, from the skin to the bone: in the latter, which is Vermale's, the knife is passed through the thick of the limb, grazing the bone, at the point where it is to be sawed, until its point appears through the skin, at the opposite side; it is then carried in an oblique direction, cutting downwards and outwards, from the root of the flap to its free margin. The performance of the operation by this mode may be rendered very brilliant and rapid, and is, therefore, in general preferred, but it is not so even and regular as the former. The knife employed should be long, thin, and finely pointed,—it may be double or single edged; in certain cases, however, the double edge is indispensable. The flap or flaps should be so formed that the large vessels shall correspond to their thickest part, being thus of course remote from the angle of junction of the incisions, and, in general, the flap in which the principal vessel is included, should be formed last; this rule, however, admits of some exceptions, which shall be noticed at the proper place. When a flap amputation is performed in the contiguity, the member is disarticulated before the second flap is formed. When this mode of operating is resorted to, in the continuity of the limb, the bone is sawed in the usual way.

On the first introduction of the method of operating by flap, its partisans assumed for it a superiority over the circular mode, on the ground of its being less painful, of more prompt execution, preventing exfoliation of the extremity of the bone, exposing but rarely to hæmorrhage, requiring no ligature of vessels, effecting a cure more speedily, and forming a better stump. Time, however, has shown how much these pretensions were exaggerated. Most surgeons now agree, that the stump is less likely to be conical than when the circular method is adopted; that the flap amputation is more rapid of execution, and covers the bone better; that the flaps may be more easily and accurately adjusted, especially in deep and extensive wounds; and probably that their reunion is more speedy and certain.

The advantages of this method, as regards the rapidity of reunion, would doubtless have entitled it to a larger share of favour, had not the progressive improvement of the circular method rendered union by first intention, in the cases in which it is employed, almost equally certain. It is better to form two flaps than one, when both can be made of equal thickness and width, as in that case the bleeding surfaces are brought together with the most perfect ease. When a single flap only is formed, it must be often extremely long, and when not sufficiently so, it becomes necessary to stretch it over the sawed extremity of the bone. This was Verduyn's method, and its inconveniences are so obvious that it is but seldom preferred. Unfortunately, however, it is sometimes the only method that can be resorted to, as, for example, on the field of battle, when one side of a limb is either carried away, or disorganized by a cannon-shot; in other cases also, its adoption is often less an affair of choice than of necessity. The motives for preferring it in certain cases will be discussed under the particular amputations.

One of the great advantages of this method, when first introduced, was the effect it had in familiarizing the minds of surgeons to the healing of the wound by first intention. But even on this point, it would appear, that their opinions were far from being firmly established, for we find, in 1765, Sylvester O'Halloran, of Limerick, proposing to renounce this important advantage, and recommending that the flap should not be applied over the bone, until such time as it should be covered with granulations.

The oblique, or oval method, consists in such a division of the soft parts, as will represent a V; each flap will thus have the form of the mouth-piece of a lute. It is simply a modification of the flap amputation, adapted to particular cases. Langenbeck first employed it in the amputation of the metacarpal and metatarsal bones; it was subsequently employed by Mr. Guthrie, in that of the shoulder-joint, and it has since been strongly recommended by Scoutettin, in other situations.

The V may be formed by two incisions, which shall divide at once the integuments and muscles down to the bone, the angle of union of these incisions being upwards, or in the direction of the trunk. In some cases, the skin alone is divided in the first cuts; it is then retracted, and the muscles are divided down to the bone. The division of the skin and muscles by separate cuts, is considered preferable, wherever the soft parts are voluminous.

The cases in which the oval method may deserve a preference will be pointed out in the particular amputations.

Measures necessary to arrest the bleeding after amputation.—These require as much attention, and perhaps more skill, than the cutting part of the operation. Dionis remarks, "le plus difficile n'est pas d'abattre une jambe, un boucher en feroit bien autant; mais c'est de se rendre maitre du sang en l'arrêtant avec promptitude et avec sureté."—It certainly is more easy to amputate a limb than to stop the bleeding afterwards; and yet how little care has been taken to impress the young surgeon with a sense of the difficulty and importance of this part of his duty. Here, a keen eye, a practised hand, and minute anatomical knowledge are especially necessary. As soon as the amputation is over and the retractor removed, the soft parts of the stump are seen tending to recede from the end of the bone. The vessels shorten somewhat after their division; they generally lie more or less concealed in the interstices of the muscles, and are not very apparent on the surface of the wound. The nerves, which shorten less, are more prominent objects upon it. The muscles are found to have retracted more or less according to the length of their fibres, and to have drawn up in their sheaths the tendons belonging to them.

The arteries are to be tied without delay; and the surgeon should secure the principal branches in the order of their volume and known position. He will do well in searching for the others, to proceed from the bone towards the skin. By this order he will save much time, and no inconsiderable quantity of blood. The ligature is the means adopted, almost without exception, now a-days, to arrest the bleeding after amputations. The principles on which its application is founded, are developed in the Articles LIGATURE, ANEURISM, and HÆMORRHAGE. (See these Articles.)

The ligatures should be round, and not larger than is required to admit of being tied tight enough to divide the internal and middle coats of the arteries without danger of breaking. Those made of inkle or silk are usually employed. It will be well for the surgeon to be aided by two assistants in securing the arteries, one to apply the ligatures, the other to hold the stump in a convenient position between his two hands, which are gently to grasp and support it. He is himself to take up the arteries, and should stand or sit quite at his ease, so as to be able to use both hands rapidly yet steadily. In the left he will hold a sponge moistened with hot water to wipe the blood from the end of the stump; in the right a forceps or tenaculum. The former is better suited for the larger, the latter for the smaller vessels. In using the forceps he is to place its branches on opposite sides of the artery, and to lay hold of it by bringing them together. With the tenaculum he is to seize it by hooking it through. Where, from the smallness of the vessel, or from its situation, it cannot readily be secured, he is to mark the spot whence the blood issues, as he wipes it away, and at that spot to lay hold of it, the instant he uplifts the sponge, and before a fresh gush of blood conceals it. When seized, the artery is to be slightly drawn out from the surface of the wound; and if the surgeon perceives he has taken anything with it, he must isolate it by transfixing it with a tenaculum behind the instrument retaining it. The assistant isolating it, is to tie it immediately behind the instrument, as he would tie up the mouth of any yielding tube. Having made the knot, at first loosely, he is to tighten it by drawing steadily on the ligature wound round the last three fingers of his hands, while his thumbs, or index fingers, serving as pulleys, direct it to the exact place where it is to embrace the vessel, but always rather away from the instrument, lest it slip off.

If a forceps is used, the noose may be first made on it and then slipped over its end on to the artery, to be there tightened. When the coats of the vessel, after gradually yielding to the pressure of the ligature, cease to give way, we may be sure the internal and middle ones are divided, and that the knot is sufficiently tight. By this the proper degree of force can always be estimated. As the ligature should be fastened by what is called a *right knot*, a second knot is to be made over the first, and care must be taken to let nothing interpose between the two[1]. Sometimes there is great difficulty in securing an artery owing to its being situated in an excavation or among tissues which conceal it and facilitate its retraction, such as aponeurotic textures[2]. In this case, if it cannot be seized with Assilini's forceps, a ligature, which is to embrace with it some immediately surrounding tissues, but as little of them as possible, may be passed round it by means of a curved needle. Such a ligature should be very strong, as considerable force may be necessary to tighten it; and if not drawn sufficiently tight to cause the sloughing of the tissues, which it includes, it might be retained by them and thus retard the cicatrization of the wound. The disadvantage of securing an artery thus mediately is in relation to its volume, because the larger the vessel the more uncertain is its obliteration by this kind of ligature; and the more likely is it to be accompanied by veins and nerves which it were well to exclude, but which cannot be excluded from it. The inconvenience of tying small arteries mediately is not very great, and many surgeons in taking them up do not make a point of isolating them with nicety.

All the arteries are to be secured which, on the tourniquet being removed, furnish blood in a distinct jet or stream, however small. The surgeon may know he has tied all those which require a ligature, when, after cleaning the stump with a sponge, he finds the blood is not renewed in sufficient quantity to prevent the uniting of any part of the wound by first intention. It is better to tie too many than too few, especially as some which from retracting or some other cause, furnish no blood for a short period from the completion of the operation, are sometimes apt to bleed afterwards; and the fewer there are taken up, the more firm and compressive must be the dressing applied to the stump. In general, the French surgeons tie more than it is customary to secure in this country, and in my opinion, more than is absolutely requisite: it is, however, erring on the safe side.

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[1] I once saw the application of a ligature to the external iliac considerably retarded by the interposition of something between the two knots. The surgeon thought it right on that account, to tie the vessel a second time.

[2] M. Ribes thinks the degree to which the anterior tibial artery retracts after division is owing to the manner in which it traverses the upper part of the interosseous ligament.

The precise number of arteries which it may be proper to tie cannot be foretold with exactness; that must depend on their volume, number, and disposition to bleed in the part, and, in these respects, they are not often the same in the same parts. The difference is sometimes very great, and may belong to a peculiar condition of the limb, induced or not by the disease which rendered amputation necessary. After an amputation performed by M. Marjolin for gangrena senilis, more than twenty arteries required ligatures; and in the amputation of an arm which had been the seat of an aneurism, treated unsuccessfully by the ligature of the brachial artery, the operator, Professor Richerand, had scarcely divided the soft parts when streams of blood spouted from about twenty large arteries which it was found necessary to tie.

Hæmorrhage from the end of the bone, which very rarely occurs, is to be averted by pressure exercised for a short time with a small thick pledget of lint, or by plugging the canal containing the bleeding artery with a piece of softened wax.

Where the arteries of the limb have undergone the bony or osteo-cretaceous transformation, more than ordinary precautions may be necessary to secure the larger ones. In most cases of this sort it will be proper to use in preference to the large flat ligature recommended by the French, a round ligature twice or thrice the thickness of that usually employed; but if an artery has become so brittle as to give way to this, I would recommend tying it over some cylindrical body introduced into its canal, and not applied externally, as advised by Scarpa, and most of the French surgeons, for I believe it to be rather in the change of form than from any constriction exercised upon it that the vessel is apt to crack.

For such arteries the French surgeons recommend the use of a broad flat ligature, and sometimes the interposition between it and the arterial tunic of a small cylinder of linen or diachylon plaster whereon to tie the knot so as to close the artery by flattening rather than by circular constriction as advised by Scarpa. But I believe that the twisting which a flat ligature makes at the knot, and which it is apt to make elsewhere, will be found more cutting, and therefore more likely to divide the artery than any part of a round one. I am, therefore, inclined to believe that we cannot do better in these cases than use a round ligature twice or thrice the size of that usually employed. If, perchance, the tunics of an artery were found so completely ossified and brittle that they could in no way be brought together without breaking, probably the best plan would be to tie them over a small plug of linen introduced into the arterial canal.

It is stated by many surgical writers, that one or more of the veins may bleed so much as to require ligatures; and it was the practice of Dessault and of Mr. Hey after amputation of the thigh, to include the femoral vein and artery in the same ligature. We confess we have never seen such a practice necessary although we conceive there may be considerable venous hæmorrhage where no valve is interposed between the junction of branches with the bleeding vein and its orifice; and more especially after amputations performed near the trunk. It ought always to be dispensed with, if possible. The pressure of the dressing will generally prevent this reflux of blood, which may be always known to be venous from its colour, and which often flows from there being some slight temporary check to its return towards the heart.

In those amputations where the circulation cannot be sufficiently commanded, and where a great number of vessels must be divided, especially, if in such cases the patient happens to be one who cannot afford to lose much blood, it may be desirable to tie the principal artery of the limb before it is divided. This is often done with advantage in amputations at the hip and shoulder-joints, either as a preliminary measure, or before the division of the soft parts is completed. Some unforeseen circumstance may also render it necessary to stop the bleeding from a large artery after its division, prior to the completion of the amputation. In a case of amputation of the thigh, in which, from the inadequacy of the pressure exercised on the femoral artery, a terrible stream of blood spouted from this vessel the moment it was divided, Dupuytren instantly seized the artery with his left hand, while with the right he completed the operation, in his usual masterly style, as if nothing had happened.

When all the ligatures are applied, it is usual to cut off one string of each of them, near the knot, in order to diminish, as much as possible, the quantity of foreign matter to be left in the wound. It will be better for the assistant to do this for every ligature as soon as it is applied. They will thus be prevented from being entangled; the time often necessary to disentangle them will be spared, and there will be no risk of cutting away both parts of the same ligature. The remaining strings are to be collected, according to their proximity to one another, in one or more bundles, each of which is to be left out at that part of the margin of the stump, where it will least interfere with the union of the wound. Here the surgeon will feel the advantage of having employed small ligatures. In general, it will be found advantageous to leave out the principal bundles at the extremities of the wound, where they serve as conductors to the escape of any pus that may form. But stray ligatures, situated far from these extremities are sometimes better brought out at the nearest point of the edge of the stump, where they may be placed between the straps of plaster used to unite the wound. Care should be taken that each bundle and each separate ligature be drawn straight, so as to lie in a straight line from the knot to the exterior of the wound; because, if they are allowed to bag, the arched part tends to prevent the union of the wound; or, what is worse, becoming enclosed between its adhesions, is the cause why the ligatures do not come away, and cannot easily be withdrawn at the proper time. Mr. Crosse, to whom I am indebted for this remark, thinks the neglect of this precaution is the real cause of the difficulty sometimes found in removing the ligatures. The above precaution having been attended to, if the surgeon find the ligature rise, which it will often do, half an inch or an inch, so that less of it is buried in the stump, he knows that it is detached and remote from the vessel; and though resisted by granulations, he does not hesitate to use considerable force to remove it.

As it is desirable to leave as little foreign matter as possible in the wound, both strings might be removed with advantage near the knot, but that the latter would not easily come away. It would have to make its escape through parts healed over it, if one string were not left to keep the path open, and would thus cause greater irritation, and retard the complete cicatrization of the stump more than an entire ligature. This has been proved by direct experience. Mr. Fielding of Hull found that knots left buried in wounds produced pain and irritation for several weeks, and even for months; and the same effects induced Mr. Lawrence to discontinue the practice of having them thus enclosed, although he took great pains, and employed the fine dentists' silk, of which the knot weighed only from $\frac{1}{10}$ to $\frac{1}{20}$ of a grain. Similar results have followed in the trials made of ligatures composed of catgut and other animal substances, which it was supposed might possibly be absorbed.

It will be proper, then, to continue the practice of leaving one string, until we discover a substance for ligatures susceptible of being absorbed without producing too much irritation.

Some surgeons of our own time have attempted to dispense with ligatures altogether. Koch of Munich has been in the habit of relying, as a sufficient means to stop the bleeding, on the exact union of the wound, and some degree of pressure exercised on it by the dressing, and on the course of the principal artery by a bandage. Other modern practitioners[1] have contented themselves with the application of ice to the stump, after closing it firmly with straps or by suture.

These and similar measures may suffice to arrest the bleeding in many cases, but in many others they would be followed by dangerous hæmorrhage. To have recourse to, or confide in them, cannot be justified on any rational grounds. They are little better than those employed by the ancients, and any attempt to recommend them must be viewed as tending rather to the retrogression than to the advancement of surgery.

Far more deserving of consideration, and probably much less hazardous, is the plan of arresting hemorrhage by torsion of the arteries, which will be fully examined in the article Torsion. It appears to us to rest upon the same phenomena, as those which explain the absence of bleeding in cases where the arteries are irregularly broken, as when a limb is torn off. Torsion may deserve to be ranked, as far as convenience and perhaps safety is concerned, next to the ligature; but is, certainly, not sufficiently safe to supersede it. Velpeau, who appears to have given it a fair trial, was obliged to relinquish it, in consequence of the dangerous hæmorrhage which sometimes followed its employment.

The results of the treatment of bleeding arteries by *Fermeture*[1] and *Folding*[2], which have been fully noticed by the same author, prove that they are less efficient than torsion.

Although the other measures we possess of arresting hæmorrhage may rarely, if ever, be needed to stop the bleeding after amputation, they are not to be entirely lost sight of by the surgeon who undertakes this operation; because, it is possible he may sometimes find it useful to call them to his aid, and when had recourse to, in conjunction with ligatures, they tend, in the proportion to which they are employed, to render a less number of these necessary.

Dressing after amputation.—The ameliorations that have been introduced, in the mode of dressing the stump, are no less remarkable than those which have marked the successive periods in the history of amputation. The system of filling the cavity with lint or charpie, and of swathing the stump with compresses, and covering with the Maltese cross, the woollen bag, or cap, and various other means formerly in use, are now very properly abandoned.

From the time when Alanson first propounded the doctrine, and recommended the immediate union of wounds after amputation, the practice has been gradually advancing in favour, till now, when it may be said to constitute an exclusive method amongst British surgeons. Many of the continental surgeons however, the French more especially, have adhered to the older mode. We have thus two general modes of dressing; viz. *by first intention*, in which the lips of the wound are at once brought into close contact, and so maintained till the parts have grown firmly together; or *by second intention*, in which contact is prevented by the interposition of dressings of various kinds, and the union when it takes place is consecutive to suppuration. At no very distant period, the propriety of attempting union *by first intention*, in cases of amputation, was warmly debated, and while M. Roux charged British surgeons with an indiscriminate partiality for this plan, M. Larrey was of opinion that it ought to be proscribed altogether in these cases, in order to remove or lessen the chance of tetanus. The adoption of this mode, however, has continued to extend, and even now many of the French surgeons of eminence employ it in the great majority of cases; and those who still oppose it, have so far altered their opinions in regard to it, as to direct their attention chiefly to distinguish the cases in which the immediate or the consecutive mode respectively, is entitled to the preference.

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[1] I think Delpech, and some of the Italian practitioners.

[1] Closing or stopping the mouth of an artery, by inserting into it a cone of alum, cut in the shape of a cone.

[2] Doubling or folding the end of the vessel back on itself, and replacing it thus folded, in the soft parts, and closing the lips of the wound firmly upon it.

Some of the French surgeons still cling to the opinion, that when the secondary union is had recourse to, the prolonged suppuration prepares the constitution of the patient better for those changes which must take place in the organism after the removal of a large limb; that when a disease of long standing has transformed a limb into an abundant source of secretion, there may be danger in drying up the morbid discharge too suddenly, and that in such case, secondary union is by far the safest; that where the tissues in which the operation has been performed are in an unsound condition, it is highly improper to confront the surfaces with a view to immediate union. These cases, however, even if we admitted the reasoning to be correct, would only form exceptions. But the circumstances here assumed as objectionable to the immediate union, are not only not proved, but they are, by English surgeons, regarded as absolutely hypothetical.

The entire body of English and American, with a majority of the best German surgeons, agree in considering that the advantages in favour of union by first intention far outweigh the drawbacks which, in some rare cases, are attributed to it, while it is indisputable that the adoption of the secondary mode of union in all cases would be much less successful than the modern plan. How many there are in whom, by the prompt reunion of the divided parts, a degree of constitutional reaction, and protracted suppuration is prevented, which had they been allowed to take place, would, in all probability, have destroyed or greatly perilled life! Could it be affirmed that the secondary union, though a slower, was always the safer process, the case would doubtless be a strong one; but the very reverse of this is the fact: in secondary union the soft parts, which, at the time the operation was performed, were ample enough to form a good covering for the bone, are often so wasted by the long-continued suppuration, the pain and hectic fever produced by keeping the constitution under this drain, that when union is at last attempted, the covering for the bone is scanty, and the stump is conical. The inconveniences of the old mode are frequently very great, and, in too many instances, persons of good constitution, who would have recovered in a few weeks had a different plan been adopted, have fallen victims to an exhausting suppuration, or to the constitutional disturbance arising from a gleety and irritable stump.

Velpeau contrasts the two modes of dressing in a very striking manner, by comparing the results of Baron Percy's practice at the head of the military surgery of France, who adopted immediate union, with that of Pelletan, his contemporary, at the head of the civil hospitals of Paris, who was strongly prejudiced in favour of the mode of union by granulation. Out of ninety-two soldiers thus treated by Percy, on the field of battle, eighty-six were cured in twenty-six days. By the same mode, Lucas lost only five out of seventy-five. Out of six operated on by Pelletan, where secondary union was preferred, five died!

The opponents of immediate union cast upon it the reproach of preventing the free flow outwards of the blood, pus, &c., that may ooze from the surface of the divided parts. The morbid products thus pent up, they say, macerate the stump, and excite irritation, which extends up the limb, giving rise to fuses of pus, between the muscles and tendons, phlebitis, secondary abscesses in the internal organs &c. But this manner of putting the question is scarcely fair towards the advocates of immediate union, every one of whom acknowledges the necessity, when such accumulations occur, of giving them a free exit. In many cases, however, the quantity of pus collected is so small, that it finds a sufficient vent along the ligatures.

The remarkable success that has attended amputations in this country since the adoption of the treatment by immediate union, is a strong reason for the preference it universally obtains. But it cannot be denied, that it now and then fails, even under favourable circumstances. What, however, is the result? The patient is in no worse condition, than if secondary union had been preferred at first. Nothing has been lost in the attempt, but the chance which the surgeon thought it his duty to give him of primary union.

The question, however, remains, whether primary union should be attempted in all cases? We think not. Parts in a sloughy state, or which have been severely contused, will not unite in this way, and an attempt to effect it, would be worse than useless. Parts when not exactly in the healthy state, however, will very often unite in the most favourable manner, and in such cases immediate union ought to be attempted. Not long since, one of the writers of this article saw Mr. Wickham, of Winchester, perform a partial amputation of the foot, in a case in which not only the bones, but the soft parts, were considerably altered; the bones so much so, that there was no necessity of following the articulations, as the knife went through the bones themselves with the greatest ease, and yet the flap and bones united rapidly and kindly, with very little suppuration.

To dress the stump properly requires great nicety and care, and it will not be too much to say, that upon these the success of immediate union must often depend. The section of the soft parts ought to be as even as possible, and made in such a manner as to allow of their covering the bone so amply, that no effort shall be required to make them do so. The bone itself should not start beyond the surface of the deep-seated muscles, but be the centre and deepest point of the hollow cone, which they ought to form.

Taking for granted that this state of the parts exists after a due performance of the operation, the surgeon now proceeds to tie the vessels, one by one. The large vessels are sought for in their situations, and being secured, the tourniquet, if one has been employed, may be relaxed, in order the better to enable him to detect the smaller vessels, by seeing the blood spirting from their mouths. These he may tie or twist. When he has rendered himself master of the bleeding, he carefully and gently applies a soft sponge squeezed out of warm water, with which he cleanses the surface of the wound and surrounding parts from blood, foreign bodies, &c., wiping them with a piece of soft dry linen. This done, he disposes the ligatures in such a manner, as to keep them free from entanglement, cutting one of the ends off at the knot, and carrying each of them out at the point of the wound to which it is nearest. If the threads are numerous, they should not be collected together, as such an arrangement might prevent adhesion between the deep surfaces of the flaps; but if only a few vessels have been tied, the ends of the ligatures may be all brought out together at the inferior angle of the wound.

The next step is to bring the divided surfaces into close contact with each other. In the double flap or oval amputations, the line of union corresponds, of course, with that of the incisions themselves; but in the circular method, they may be brought together, either in a vertical, or horizontal line; that in which the bone will be best covered, and the stump best shaped, ought to be preferred.

The object in confronting the divided surfaces is to obtain and maintain contact between them at all points. It will not be enough to have the lips alone in coaptation—contact must also exist in the depth of the wound. The loose soft parts, therefore, are drawn gently down over the extremity of the bone, and the wound is evenly closed from the bottom, the edges of the skin forming a straight line, corresponding to the small diameter of the limb. An assistant maintains the apposition, by pressing with the palms of both hands, while the surgeon, with both hands, takes a warm adhesive strap, and after applying one end of it to one side till it sticks firmly, carries it over the closed lips of the wound, and causes it to adhere in the same manner on the opposite side of the stump. In general, the first strap is applied over the centre of the wound, more especially when the line of union is extensive. Other straps are applied in succession, until the coaptation of the entire line is completed. When the straps are cut of equal width, small spaces should be left between them, more especially at the lower part, to admit of the escape of pus, or other matter from the wound. Some surgeons provide for this by making the adhesive straps somewhat narrower at the point that crosses the line of union than any other.

Moderate compression will be required to effect complete coaptation at the bottom of the wound, and for this purpose, two linen compresses should be applied at each side of the base of the stump, which may be secured in the roller. The advantage of this will be, that as the roller prevents the retraction of the muscles, and gives the tissues that degree of support that protects them from the fusing of pus, so will the compresses prevent the formation of a large cavity at the bottom of the wound, which, even though the lips remained well closed, would result from the separation of the flaps at a greater depth from the surface, and in which an extensive suppuration might take place, and destroy the chance of speedy union and cure.

The adhesive straps may be lightly covered with a piece of lint or fenestrated linen, spread over with simple ointment; one or two lengths of soft linen, or lint folded as compresses, will complete the dressing.

The best authorities in this country recommend the application of the roller, not only to give support to the dressings, but to prevent retraction of the muscles, and the conicity of the stump. The mode in which it is recommended to be applied by Alanson, Louis, Richerand, and Sir A. Cooper, is to make the first turns on the trunk, thence carrying it down the limb in circular turns.

In the circular amputations, few surgeons in this country at the present day ever employ sutures to keep the edges together; with ordinary care, the roller and adhesive plaster being found sufficient for that purpose.

Care after amputations.— As soon as the stump is dressed, the patient should be carried to bed, and if he feel faint, a little wine should be given. He should be made to take an easy position in bed, and the stump should be protected by means of an iron or wooden semi-circle, which will at the same time suspend the bed clothes. The stump itself should rest on a pillow or cushion in a horizontal position. It is recommended by some surgeons to elevate the stump, in order to procure the complete relaxation of the muscles, and diminish the tendency of the blood towards the wound. This elevation, however, may be carried too far, and most probably the horizontal position, recommended by Hippocrates, in which the limb approaches the state of semiflexion, is the best. In the larger amputations, the pain and loss of blood are sometimes so considerable, that the powers of the patient soon after the operation seem to be greatly depressed. It will be, therefore, proper to administer some anti-spasmodic or stimulant, and keep every thing about him in a state of perfect stillness, that the depression under which he labours may dispose him to sleep. It will be often found useful to fix, by straps or strong pins, the stump to the cushion on which it is supported, to obviate the agitation, twitching, and subsultus, which might else either interrupt or even prevent sleep altogether. Sometimes the spasms of the stump occasion great distress, preventing sleep for a long time, and exposing the patient to the misfortune of having a conical stump. When this is the case, recourse must be had to the free use of camphor and opium, to the compression of the limb with a bandage, and to the proper fixation and semiflexed position mentioned above. In the old methods of amputating, spasm was a very formidable occurrence, often defying all control, and terminating in tetanus and death.

After amputations as they are now performed, these spasms decline in general from the first day, when they are at the highest, to the fourth or fifth, when they generally disappear. It has been observed that those who, by an effort of heroic constraint, repress every manifestation of suffering during the operation, are peculiarly predisposed to spasm. There is nothing surprising in this: the effort must greatly exhaust the nervous energy of the patient, and be thus conducive to nervous accidents. He should be directed not to impose too stern silence upon his pains; his cries of distress are not only natural, but assuaging.

The immediate union of the wound will be best favoured by keeping the stump cool. Cold, or iced water is employed for this purpose; and some surgeons steep their compresses in water containing a certain portion of spirit. When the stump is kept wet, a large piece of oil-cloth should be made use of to protect the bed, Cold may be applied still more commodiously by enveloping the stump in one or two bladders, partially filled with cold or iced water, to be changed for others when the temperature increases. One of the best topical refrigerants with which we are acquainted, is produced to hand by putting powdered camphor between two pieces of cambric, and applying them wet.

Accidents that may arise during the operation.—The most formidable of these is hæmorrhage. Notwithstanding the resources we possess in the tourniquet, compression by the hand of an intelligent assistant, the pad, key, &c., cases occur now and then, in which, from particular causes, a considerable quantity of blood may be lost. This may arise from a variety of causes: the means for preventing the hæmorrhage may have been badly applied, or the individual case requiring the operation may be of such a nature, that they cannot be properly applied; or again, the tissues divided may be so abundantly supplied with blood-vessels preternaturally dilated, that the compression is ineffectual.

When the hæmorrhage is so abundant as to endanger life, there is no time to be lost; the operation must be terminated as speedily as possible. Three or four of the principal bleeding vessels may be commanded by the assistants, while the surgeon applies rapidly and successively his ligatures; or, if several torsion forceps be at hand, the mouths of the bleeding vessels may be locked in their beaks, and thus held until the surgeon can tie them at his ease. This instrument will be found invaluable in these cases; more especially in amputating on the field of battle, where the assistants are few in number. When the amputation is performed with flaps, an assistant can make compression on the principal vessels, by grasping in both hands the whole mass of the flap itself, and ligatures may be applied at once, without waiting till the bone is sawed off.

The hæmorrhage may arise from the veins; in which case, it may be caused by the compression made upon the limb. In a case in which one of the writers of this article performed an amputation of the thigh for a diseased knee-joint, with extensive ulceration, and abundant suppuration, no sooner was the tourniquet applied, than the venous blood, the return of which it prevented, burst out, in black and copious streams, from the ulcerated cavity at the joint.

It has been recommended to tie the bleeding veins in such cases—a practice which ought, if possible, to be avoided. If the bleeding depends upon undue pressure, it will cease upon its removal. The return of the venous blood may also be checked by the patient's straining and holding in his breath, in which case, he should be directed to breathe freely, and refrain from effort of every kind.

It sometimes happens, when all the bleeding vessels have been tied, and the dressing is completed, that an oozing of blood takes place, or even some of the small vessels, that on exposure, had retracted, and immediately ceased to bleed, furnish blood afresh, as soon as the patient has become warm in bed. This effect of re-action requires to be carefully watched. Dupuytren, in order to obviate this occurrence, used to defer the dressings for several hours, in expectation, that on recovering from the shock of the operation, these small vessels might be discovered and secured. It will be best prevented by the application of cold to the stump. The bleeding from the capillaries may depend on the tightness with which the roller is applied; and, should such be the case, it should be slackened. If the quantity effused be not sufficient to produce a feeling of distress from tension, it will be best not to disturb the dressings, further than to slacken the roller, remove the compresses, and expose the stump to the action of the cold; for this purpose the compresses may be kept wet, or ice may be applied in bladders.

The hæmorrhage may arise also immediately after the operation, from the ligature slipping off the vessel. In this case, the tourniquet, if it be left on the limb, should be immediately tightened, or the vessel may be controlled with the fingers; the dressings should then be removed, and the vessel secured effectually by placing the ligature in a proper manner; if the coats of the vessel have given way, it should be drawn out, and tied with a round or thick thread, which will make sufficient pressure, without cutting the vessel across.

Removal of the first dressings.—If there be nothing in the stump to call for particular attention on the part of the surgeon, the first dressings should be allowed to remain undisturbed till the fifth or sixth day. Any considerable accumulation, however, of blood in the cavity of the stump, by acquiring irritating qualities, or tightening the adhesive straps to a painful degree, will require a much earlier disturbance of the dressings. Their renewal is in general much dreaded by the patient; but, if the surgeon proceed methodically, and with due care, he will not give any pain worth speaking of, nor will he disturb the adhesions already formed between the edges of the wound. The blood and serum which has glued all the dressings, being now dry and hard, should be softened with soft sponge dipped in warm water, or the water may be made to fall in a gentle stream upon them, until they become thoroughly softened, when they will separate easily. The roller and compresses are removed first, and then the adhesive straps in succession. If the stump be large, each strap should be removed, and replaced by another before the next strap is disturbed; by this means, only one point of the wound is deprived of support at a time. Before the application of the fresh strap, the exposed part of the stump is gently spunged and wiped dry.

In detaching the ends of the straps, they should be raised, first, on one side, till the skin is uncovered nearly down to the edge of the wound, and then on the other side, approaching the wound in the same manner; both ends are then laid hold of, and gently raised perpendicularly from the surface of the stump. It is not uncommon for some of the small ligatures, to come away with gentle traction on the fifth or sixth day; the larger ones may be removed on the tenth or twelfth. If they should remain after the fifteenth day, gentle tractions should be made on them at each time of renewing the dressings.

Secondary accidents after amputation.—At the period when the ligatures come away, and even long after, hæmorrhage may take place. The healing of wounds from amputation by immediate union has tended more than any thing else to diminish the frequency of this accident. In this mode, the divided vessels are not exposed, nor irritated by any thing, beyond the ligature itself: they are covered by, and in contact with parts living like themselves, and with which they soon become intimately united. One of the great causes of the inflammation of the stump and its vessels is thus guarded against, and the ulceration, through means of which the ligature is freed from the vessel on which it had been applied, is in almost the universality of cases limited to that point alone.

It does, however, happen, in some rare cases, that inflammation and suppuration taking place in the coats of the arteries of the stump, the coagulum, instead of becoming organized and obturating the vessel, is expelled, and hæmorrhage occurs, at a period when the stump is all but completely healed, the blood flowing from the fistulous tracks of the ligatures.

Secondary hæmorrhage may also occur, when the stump having been attacked with inflammation, the soft parts become sloughy. Under these circumstances, the obliteration of the vessels does not take place, and the blood may burst out from one or more of these vessels at the same time, or in succession. This is observed to occur in cases where amputation has been performed for mortification of a limb arising from internal causes, or when the vessels had been in a diseased condition prior to the operation.

The period at which consecutive hæmorrhage may occur, will vary according to circumstances, from the end of the first to that of the fourth week, and is, generally speaking, a very serious and often unmanageable accident.

When the artery has been re-opened by the progress of sloughing or ulceration, it will, perhaps, be hopeless to attempt securing it again in the same place where these morbid processes are in activity. Sanson, however, was successful in a case, where he secured the mouth of the bleeding vessel, including in his ligature a portion of the soft parts which he dissected for some way upwards.

It has been recommended to make compression on the course of the arterial trunk, by means of a pad. J. L. Petit was successful with an instrument called a *garrot*, which he invented for a case of this kind, and by which a pad might be pressed on the course of the artery or a piece of sponge or agaric might be maintained against the bleeding mouths of the vessels themselves. This mode of using compression, particularly in thigh stumps, has been favourably spoken of by White and Hey, but they prefer compression by the hands of assistants who would take the duty in turns; the pressure to be kept up until granulations arise, and all likelihood of a return of the hæmorrhage ceases. The fatigue to which the assistants would be exposed in this service might be easily spared, as the materials with which it is made, either agaric or sponge, might be readily applied, with proper and regular force, by means of a compress and roller.

Should all these means, however, be unsuccessful, the surgeon has still in reserve a precious resource in the ligature of the artery higher up in the limb. Having determined on the point at which the vessel is to be tied, he cuts down to it, and places the ligature upon it, as in the operation for aneurism. In this object too, he is not quite certain of not being disappointed; for the vessel may be unsound even here, or, what is more likely, the collateral vessels may still continue to carry the blood to the perforated vessel, from which the hæmorrhage took place. M. Roux, who recommends the practice, had a patient in the Charité on whom he amputated the leg. Secondary hæmorrhage, from ulceration of the popliteal artery, compelled him to tie the femoral artery, but the hæmorrhage was only momentarily interrupted: the blood conveyed by the collaterals into the lower part of the artery gushed out as fiercely as before, and the unfortunate patient, was obliged to submit to have his thigh amputated to save his life.

There is another form of consecutive hæmorrhage, mentioned by Gouraud, resulting from the irritation of a necrosed bone. Compression will have no effect in arresting it: the dead bone must be removed, and the dead soft parts cut away, before the hæmorrhage, which is sometimes considerable, can be commanded.

But whatever be the plan resorted to for checking the hæmorrhage, if the soft parts of the stump are in a sloughy state, or otherwise ill-conditioned, their vitality must be modified before they will put on healthy action. For this purpose, Hey recommends the application of lint soaked in equal quantities of lemon juice and rectified spirit of wine.

Inflammation of the Stump.—When the surfaces have been properly put in contact, the dressing performed without making undue compression, and the stump is kept cool, it will seldom inflame; but on the contrary, the reaction will be slight, and adhesion will be found to have taken place extensively, often indeed at all points, except those occupied by the ligatures. It sometimes, however, happens, possibly in most cases from want of proper attention at the time of applying the dressings, that blood effused from a neglected vessel, or pus thrown out from surfaces irritated and indisposed to adhesion, stagnates at the bottom of the wound, thus forming a focus, from which inflammation of an unfavourable character extends over the whole stump. At first there is an increase of the local pain, the parts swell, and the feeling of constriction becomes more and more distressing; the pulsation of the vessels becomes sensible, extending towards the trunk; the edges of the wound are gaping, and of a livid red. The pulse is full and frequent, the countenance flushed, the eyes brilliant, the tongue red. If the dressings be not speedily removed, the traumatic fever reaches its height, and delirium supervenes.

No time should be lost in removing the adhesive straps and freeing the stump from all constriction. It may be fomented, or at once enveloped in an emollient poultice. If the inflammation is allowed to proceed unchecked the lymphatic vessels redden, and the ganglions swell, the muscles retract, the wound bursts open, giving issue to a small quantity of dirty pus, and its surface exhibits a greyish hue; this inflammation is of the erysipelatous kind, and prone to terminate in gangrene. Vigorous and vigilant treatment, local as well as constitutional, will now be necessary, not only to avert the danger with which life is threatened, but to prevent such extensive sloughing, as would deprive the bone of a proper covering, and expose the patient to the miseries of a conical stump.

Sometimes the mere exposure of the parts, and the cessation of all constriction upon them, will give a sufficient check to the progress of the untoward symptoms. Sometimes, however, this will not be enough. The local symptoms still persist, resembling closely those of hospital gangrene; abscesses are formed here and there, and extend upwards; and low fever, with stupor, or excessive prostration supervenes. In this state, various remedies, both local and general, may be had recourse to; some surgeons combat the inflammation by covering the surface of the stump, with leeches, emollient poultices, or emollient and narcotic fomentations; some prefer free and deep incisions. Larrey, Dupuytren, and others speak highly of the actual cautery. The general indications are those of typhoid fever.

Conical stump.—Louis was the first who discovered the real cause of this evil. The retraction of muscles depends on the number and length of their fibres, and is proportionate to these two conditions. If two muscles be cut across, the fibres of one being three times longer than those of the other, the retraction in two portions of the longer fibres will be three times as great, as in two portions of the shorter; the third or internal portion of each retracts least, the fibres are shorter, being internal, and united to the neighbouring parts by more dense cellular tissue. The looseness or density of the cellular tissue, which connects them with the surrounding parts, contributes also to the extent of the retraction. Since the mode of dividing the muscles recommended by Cheselden and J. L. Petit was adopted, the conicity of the stump, which was formerly a frequent consequence of amputation, is now but very rarely observed; it however occurs sometimes from miscalculation as to the size of the flaps, but much oftener from retraction of the muscles, in consequence of sloughing, or long continued suppuration.

The greatest number of conical stumps occur after field amputations, where, from the hurry attendant on their performance, imperfect dressings, and the want of sufficient assistance, the parts inflame, suppurate, and retract.

After retraction, the muscles are seen drawn high up in their sheaths; the external layers are the most retracted, the internal still adhering to the bone, which, contrary to the rules of the art, forms the centre of a projecting instead of a hollow cone. When conicity is the result of miscalculation on the part of the surgeon, at the time of the operation, Mr. Guthrie recommends the removal, by the saw, of such an additional portion of the bone as will allow the remainder to be well covered; and he thinks it is better to do so at once, before attempting to dress the stump, than to expose the patient to the necessity of undergoing another operation at a future time. The surgeon should bear in mind that the degree to which the muscles retract, varies in different subjects, that his calculation may be erroneous from œdema, or fulness of the limb, and that he must endeavour to be on the safe side by saving sufficient soft parts to form a good covering.

Abscesses and sinuses of the stump and limb.—As a consequence of inflammation, matter in more or less quantity may be formed in the stump, and being pent up, it burrows, and extends into the neighbouring parts. Its progress upwards is facilitated by tracks of cellular tissue lying between the muscles and by the open ends of tendinous sheaths. Some amputations, such for instance as those of the wrist and tarsus, are peculiarly liable to this accident, owing to the numerous synovial sheaths which surround the stump. The most serious consequences may arise, if this diffusion of the matter be not prevented in time. Counter-openings must be made, wherever they are required, to give a clear and speedy exit to the pus. The mode of forming those counter-openings has been already described in the Article Abscess. The reaccumulation of the matter must be guarded against by the proper application of graduated compresses along the track of the sinus, and expulsive pressure should be gently made at each time of dressing, in order to prevent any lodgment. With due care, and a proper outlet for the matter, the frightful mischief which would arise from its extension up the limb, will be prevented.

Necrosis.—When amputation is performed according to the rules laid down in the preceding part of this article, all proper precautions having been taken to preserve the life of the bone, this accident will rarely occur. With the older surgeons, who held to the pernicious practice of scraping the bone, and detaching from it, the soft parts, and the periosteum, the death of some portion of the bone, was not only an ordinary, but an inevitable event. Now, as well as then, it is most commonly the consequence of want of protection, or sufficient covering from the soft parts.

But in some rare instances, the exfoliation may arise from the injury done to the bone by the operation, or in consequence of its being in a diseased state. The bone may also become denuded, and exfoliate from violent inflammation and long continued suppuration, or sloughing of the stump.

M. Renaud mentions another cause of necrosis, viz., the inflammation of the medullary membrane. According to his observations, the periosteum is detached, and the bone dies in the extent occupied by this form of inflammation; abscesses are also formed in the vicinity of the bone. The stump itself, though not inflamed, has a doughy feel; and in some instances, a yellowish hue; and the suppuration is abundant.

When only a small portion of the bone is affected, it will be thrown off, in some cases, after a considerable lapse of time, in the form of a ring, and the stump heals immediately. When the sequestrum extends to the height of several inches, it is a debated point whether it should not be resected out at once, or left to be detached by the slow and natural process of separation. Some surgeons represent this as a very trifling, others as a most serious operation; and both opinions are correct, according to the nature of the case. When the portion to be removed is small, and easily accessible to the saw, the operation will be but a very trifling one; but when, on the contrary, the skin and muscles have shrunk away from the bone to a considerable extent, its removal may be likened to a second amputation. Bertrandi recommends a perpendicular fork of wood, whereon to rest the necrosed bone, while the saw is applied to it close to the flesh. When exfoliation takes place, long after amputation, the sequestrum may be sometimes detached by the forceps; and as a preparation for this event, it will be proper at the time of dressing to shake and work on its end; if it vacillates in any degree, the attempt may be made with somewhat greater force.

Velpeau affirms that necrosed portions of bone are sometimes shut in by the surrounding soft parts, and that the cure takes place without their being detached at all. He mentions a case where the stump suppurated, in which the ends of the tibia and fibula were completely necrosed. After remaining exposed for a long time, they became gradually lost in the soft parts, and cicatrization took place.

When there is considerable denudation, and it becomes necessary to remove the dead bone, care should be taken to detach the muscles to a sufficient extent to secure a good covering for the remaining portion, and in so doing, to avoid as much as possible the great vessels and nerves.

Cystitis.—When amputations have been performed for the removal of a considerable extent of parts, the abdominal limb for instance, a degree of irritability in the bladder, in some rare instances, proceeding to inflammation may be observed. This phenomenon in all probability is nothing more than a modification of the reactionary effects of the operation. Some surgeons, however, explain it in a different way, from observing that its occurrence is coincident with the application of a blister. At all events, it is certain, that we are sometimes compelled to use a catheter after amputation in persons who had never previously felt the slightest symptom of derangement in the functions of the urinary organs, and taking it therefore for granted that such a predisposition exists, we should be very circumspect in the employment of such remedies under the circumstances.

Phlebitis.—The phenomena accompanying this species of inflammation have been long known, but the rationale of their development has been till very recently but imperfectly understood, and even now the ingenious theory on which it rests is not universally acknowledged.

The inflammation of the veins, either alone or in connexion with the surrounding parts, is manifested by symptoms, which deserve particular attention, for it is only by taking such steps at the very outset, as are calculated to arrest their progress, that we can hope to save the patient's life. When pus is formed in the veins, and the internal organs are irritated by the circulation of this fluid with the blood, the patient's doom may be said to be sealed, as the case is almost beyond the resources of art.

The inflammation of the veins is marked by a train of local and general symptoms: the stump feels tense, swollen, and excessively painful; the removal of the dressing, however carefully performed, is torture to the patient; the fever runs high, and is continued beyond the ordinary period; the tongue becomes dry and dark, and the strength gradually fails. The course of these phenomena is rapid. Matter is soon formed, which, mixing and circulating with the blood, gives rise to another and more formidable train of symptoms: the patient has sharp rigors, and is very much agitated; to these succeed a burning hot stage, and an abundant and clammy perspiration; the countenance is sunk and earthy, the pulse frequent, small, and trembling; the skin is clammy, or very hot and dry; in a word, the traumatic has been converted into a typhoid fever, and the prostration of strength is extreme. The adhesions that had taken place in the stump are dissolved; the character of the suppuration is altered; the surface of the wound is greyish and gleety; burning pains are felt up the limb; the muscles retire within their sheaths, and the bone protrudes.

If we now turn our attention to the pathological alterations that have taken place in remote organs, we shall see how extensive and deadly the lesions are which follow the inflammation of the veins. Collections of pus are found in the lungs and liver, in the serous cavities, and in the articulations; they are also found, though less frequently, in isolated focuses in the spleen, kidneys, or diffused in the cellular tissue, and even in the substance of the muscles. In the parenchymatous organs these focuses are observed, sometimes in the same organ, progressing through the various gradations between a simple stain or ecchymosis and a true purulent collection. Analogous differences are observed in the conditions of the altered product itself; in some instances, as in the lungs, pure pus may be pressed out of the small branches of veins; in others, as in the liver, the pus seems to be blended with, or infiltrated into isolated points of the organ which are softened, and of the consistence of cheese; the circumference of these points is highly injected.

Some years ago, it was supposed by Velpeau, Ribes, and others, that these formations were produced by the deposition of pus which had been absorbed at the suppurating surface. This was the opinion of Quesnay, who imagined that the pus was not formed in the vessels, but that, being carried into them by the absorbents, it was subsequently deposited by those vessels throughout the different organs of the economy.

M. Dance's researches on this interesting subject, have led to a different and perhaps to the correct explanation of the mode in which these lobular alterations are produced. M. Dance states that the pus formed by the local inflammation of the veins is intimately mixed with the blood, which being thus rendered more fluid, is extravasated in the cellular interstices of the organs; it here acts as a foreign body, determining an inflammation of a peculiar character, passing rapidly through its several stages, and terminating necessarily in suppuration. (See Purulent Depôts.)

When the first symptoms of this very formidable accident are observed, it will be best to soothe the stump with emollient and narcotic fomentations or poultices. General bleeding will be indicated according to the state of the patient. In the second stage, the strength of the patient must be sustained, and for this purpose, wine and bark have been favourably spoken of. Blandin was successful in a case which he regarded as hopeless, by powerfully exciting the secretions, and by the use of blisters, both to the limbs and trunk.

The other accidents common to operations in general, such as, excessive pains during and after the operation, lipothymiæ, and even death itself, will be noticed under the proper head, Operation.

Progress of cure in the stump.—When the process of cicatrization goes on without interruption, it differs in no respect from what is observed to occur in other wounds. The period immediately after the amputation, and up to the third or fourth day, is marked by the twitchings and spasms of the limb, and a degree of inflammation, in general slight, which is necessary for the accomplishment of the adhesive process. When the stump is kept cool, the traumatic fever is slight, and the sympathetic disorder of the remote organs is scarcely perceptible.

As soon as the wound is completely cicatrized, the edges are puckered all round ; the muscles converted into a whitish fibrous tissue, the blood-vessels transformed into ligamentous cords, and the nerves are all blended together in the cicatrix. The nerves are enlarged at their extremities, sometimes to a considerable size. These productions are formed by the indurated neurilemma, and are often the seat of pains, which are felt more especially at the changes of the weather.

The sawed extremity of the bone undergoes also considerable change: the first effect of the reaction is a tumefaction of its tissues. A gelatiniform secretion takes place both from the periosteum and the medullary membrane ; it is shed over the whole osseous and medullary surface, and is finally ossified. When this process is completed, the tumefaction subsides, and even the bone becomes as it were atrophied, so that its end grows smaller, and more pointed, adhering to the cicatrix in the same manner as the surrounding soft parts.

Modification of the constitution after the ablation of a limb.—When the general health is perfectly re-established, it often happens that the person who has a limb amputated, becomes suddenly corpulent. This is easily explained ; the quantity of food consumed being the same, and the quantity of parts to be nourished being diminished, the nutrition is relatively augmented. The effect of this plethora is often manifested in palpitations of the heart, headach, somnolency, &c. The practitioner should check any tendency to congestion by appropriate means, by bleeding, purging, &c., until such time as the equilibrium becomes finally established, and the economy is habituated to the new state of things.

PARTICULAR AMPUTATIONS.—SUPERIOR EXTREMITY.

So great is the value of the least portion of the thoracic limbs, that the rule, in regard to the amputations to be performed on them, is to preserve all we can ; or, in other words, to operate at the most remote point from the trunk, at which the lesion requiring amputation will allow. With the caution thrown out, as regards articulations, particularly those of large extent, it may be stated, that amputation, on the various parts of the thoracic member, may be performed either in the continuity or in the contiguity : the points for operation being at various parts of the fingers, at their joints with the ends of the metacarpal bones, or in the continuity of these bones, at the carpo-metacarpal and wrist-joints ; at various parts of the forearm and arm, at the elbow and shoulder-joints, and amputation has even been performed on the clavicle and scapula.

AMPUTATION OF THE FINGERS.

The amputation of the fingers is scarcely mentioned by the ancients. When first resorted to, it appears to have been generally performed in the continuity, and as late as the time of Fabricius Hildanus, it was the custom to chop off parts of the fingers, with a kind of hatchet, or with a chisel and mallet. At the present day, it is most commonly performed at the joints. It is, however, unquestionably, in some cases, more advantageous to saw through the bone ; when the injury is limited to the joint, it will be better to amputate just beyond it, than to pass a whole phalanx length of sound parts to reach the next joint. This opinion is supported by Ledran, Velpeau, Guthrie, and many other English surgeons.

In these, as in all other amputations, the operator should bring to his mind the anatomical structure of the parts on which he has to act. The fingers are formed, each of three phalanges, somewhat convex posteriorly, and slightly concave on their palmar surface. On their dorsal surface is expanded and fixed the tendon of the extensor muscle, a small quantity of cellular tissue, and a fine and sensitive integument covered anteriorly by the nail. Fixed to their palmar surfaces, lies a fibrous sheath, lined by a synovial membrane, which is reflected from the two flexor tendons it contains. One of these tendons is inserted into the tubercle of the third phalanx, whilst, the other held close in its place by a fibrous band, is implanted by two strips, one on each side into the second phalanx at about its middle. There is, besides, a good deal of cellular tissue modified to support the skin which is here converted into a membrane of special sensation. There are also two arteries, one at each side, with their accompanying veins, and two large nerves similarly disposed, which exhaust themselves chiefly on the skin, at the end of the last phalanges. The digital articulations, strictly so called, are ginglymous ; the metacarpo-digital or knuckle-joints are enarthrodial.

The bare enumeration of the parts entering into the structure of organs devised for such admirable and infinitely varied motions, and connected by an additional bond of sympathy with the rest of the economy, as the organs of touch, will be sufficient to warn the surgeon that the ablation of them may be sometimes attended with serious consequences. When inflammation arises, it is easily propagated along the sheaths to remote and important parts. It will also be obvious that the soft parts on the palmar are better adapted than those of the dorsal surface, to form a flap, and that compression by the dressings instead of ligatures, may, if the surgeon pleases, be employed to stop the bleeding.

The bones of the fingers are large in relation to the quantity of soft parts from which the covering after amputation is to be derived, and when sawn through, present a large extent of sharp edge to the skin, which is almost their only covering. Whilst, on the other hand, their articular ends present a round surface for this covering. Amputation at the joints of the phalanges is, therefore, a better operation than that performed in the continuity of these bones; but its superiority is not so decided as to compensate for the loss of the least portion of the finger that may be useful; consequently, it should be performed in preference when it inflicts less curtailment than the other, unless the portion be too short to be of any use (the limit in point of utility may be stated at one-half for the last, and one-third for the first and second phalanges), and it should, of course, be preferred when the curtailment by either operation would be about the same.

Some have advised, rather to remove the whole finger than to leave the first, or any part of the first phalanx; because, say they, this phalanx having no flexor tendon inserted into, or bound down to it, would yield to the extensor, and stand out so as to be inconvenient. But this opinion appears to be erroneous, inasmuch as the end of the tendon becomes blended in the cicatrix or fixed to the bone, so as to move the latter. There is, therefore, no reason to remove a portion of the finger, because the tendon is not attached to it, still less to adopt the suggestion which Lisfranc makes to incise or lay bare the tendon, and which might cause troublesome inflammation. It is, besides, an oversight to say, that the tendon has no attachment to the bone, it being in reality so attached by a white fibrous bridle to this first phalanx.

Although a surgeon may amputate portions of a finger with tolerable facility, unaided, it will be better to have the finger presented to him extended by an assistant, who will support the hand, and keep the other fingers bent in the palm.

There is some difference as to the celerity with which amputation of the fingers may be performed by these two methods. When the phalanx is removed by disarticulation, it is done almost in the twinkling of an eye; but when the bone is to be sawed, it is more tedious. But whether in the contiguity, or in the continuity, the operation may be performed, perhaps, with equal advantage, either by the circular or the flap method.

Circular method.—The skin, with its cellular tissue, is to be divided round the finger with a narrow scalpel, or bistouri, and then drawn back or dissected off, to the extent of about half the small diameter of the phalanx; a second incision is to divide the fibrous tissues, and make a track for the saw, at the place to which the edge of the skin has been retracted, and there must the bone be sawn through. The surgeon will find it advantageous to use what the joiners call a dove-tail saw, and while sawing the bone to place the finger on a firm cushion. When the surgeon operates in the contiguity, he is to open and cut through the joint, after the divided skin has been drawn back to it, in the manner described in the flap amputation. The circular method is much employed in England, and is, for the formation of a good digital stump, as good as any other.

Flap method.—The flap method for the removal of the fingers includes several different modes. It may be performed with a single palmar or a single dorsal flap, according to Lisfranc's plan; or by a right and left flap, cut from the sides of the finger, according to Maingault's plan, which is justly censured by Blandin; or by a dorsal and palmar flap, each of equal length; or, in fine, by a dorsal and palmar flap, the latter being made longer than the former.

With a single palmar flap.—In Lisfranc's mode of performing this operation, the hand in pronation, the phalanx to be removed is bent, the edge of the knife is made to enter at the side of the finger about a line or two in front of the transverse fold of skin that marks the situation of the joints. The edge of the straight bistouri being inclined, as if he aimed at the centre of the condyle behind it, the joint is opened at the first stroke; the handle of the bistouri being now brought down to the horizontal, the edge comes in contact with the skin at the back of the joint, which, with the extensor tendon, it divides, laying open the joint itself. The lateral ligaments being stretched are easily divided by inclining the edge, first to one side, and then to the other. The operation is terminated by forming a semicircular flap of sufficient length from the soft parts of the disarticulated bone, by directing the edge of the bistouri nearly parallel to the bone, from behind forwards.

Fig. 9.

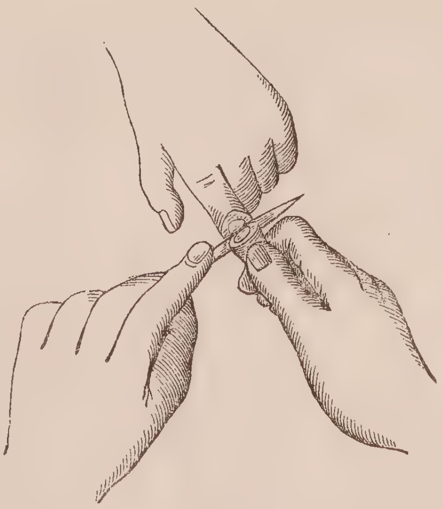

Fig. 9, *Lisfranc's method of amputating a finger: the flap is taken from the palmar surface of the phalanx to be removed. The surgeon is operating on the left hand, and holds the knife in his left hand.*

With practice upon the dead subject, these several steps may be executed with such rapidity as to form but one continuous sweep. In forming the flap, we should be very careful to have it of the proper size. Delpech used to ascertain the proper length of the flap, by measuring it against the articular head which it was destined to cover, before he completely cut it. This operation may also be performed by passing the bistouri flat, from side to side, through the soft parts in front of the joint, on the palmar surface; then lifting up the flap, laying open the joint, and completing the division by carrying the knife out at the dorsal side.

With a single dorsal flap.—In forming the flap from the dorsal integument, the first process above described is reversed. The phalanx to be removed is presented in supination; the skin being retracted by an assistant, is divided transversely about a line or two in front of the palmar fold of the joint; the sheath, tendons, and articular ligaments are next divided, and a semicircular flap is formed from the skin of the phalanx which is to be removed.

In the former plan, the cicatrix being on the back of the finger is more exposed; but to compensate for this disadvantage, the flap cut from the palmar surface is thicker and protects better. The dorsal flap, in general, is only had recourse to where the palmar soft parts have been too much damaged to make a good covering for the end of the bone. In forming the palmar flap, the tendon, owing to the obliquity of its section is liable to protrude beyond the skin. In such a case, the protruding portion must be removed; and, for this purpose, it will be best to employ strong clean cutting scissors.

With a palmar and dorsal flap.—The phalanx to be removed is presented bent and in pronation. An assistant, holding the hand, keeps the other fingers strongly bent out of the way of the knife. The surgeon takes hold of the end of the finger, and determining the situation of the joint, which will be about a line below the sort of knee formed by its bend, he cuts with a narrow bistouri, a semicircular flap, between three and four lines in length, with its convexity towards the nail, proceeding from one side of the joint to the other; this flap, which is almost entirely skin, being raised as far as the joint, and upheld by an assistant, the joint is laid open, and its ligaments divided in the manner already described. As soon as the articulation is quite gone through, another semicircular flap of the same or greater length, is formed from the phalanx to be removed, by carrying the edge of the bistouri obliquely from the under surface of the bone to the skin.

Fig. 10.

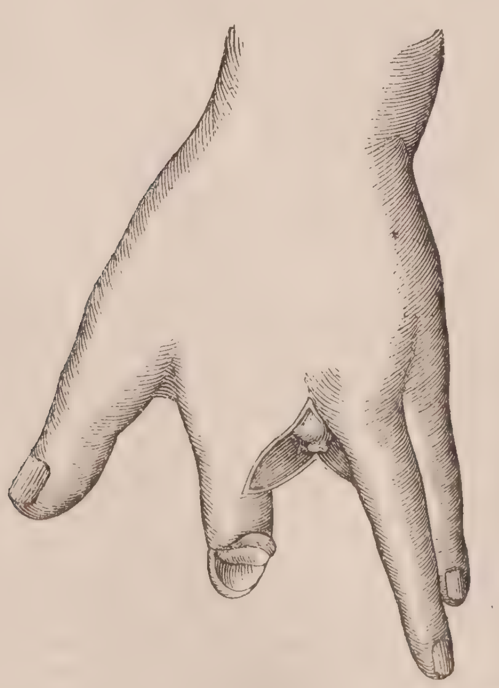

Fig. 10 *represents the amputation of a finger with a double flap, palmar, and dorsal. It has also been made subservient to the illustration of the amputation of a finger from the hand, the subject treated of in the following section.*

The hæmorrhage is trifling and soon ceases, either spontaneously or by compression. The flaps brought into contact, by straps of diachylon, or isinglass plaster, one or two small compresses may also be applied to protect the stump, which should be kept cool; and the arm should be worn in a sling.

AMPUTATION OF A SINGLE FINGER AT THE METACARPO-DIGITAL ARTICULATION.

The form of the knuckle-joint is an *enarthrosis*, with loose ligaments. Owing to this disposition, the situation of the joint can be at once made visible by drawing on the finger. The space made between the two articular heads of the bones, if the phalanx be now bent, will disappear, becoming occupied by the rounded extremity of the metacarpal bone. In the healthy state, the articulation will be found about an inch, or somewhat less, above the commissures of the fingers, the prolongation of the soft parts here forming a sort of *web*. The flap and oval methods are best suited to this amputation.

Flap method.—The hand in pronation, one or two assistants support and remove the sound fingers out of the way of injury; the surgeon takes hold of the finger to be amputated, and ascertains in the manner described above, or by moving it, the precise situation of the joint. With a straight bistouri he commences his incision from a point three or four lines behind the joint, directing it towards the centre of the commissure, which it divides, and is then continued in the same direction in the palm of the hand, till it nearly reaches its transverse fold, beyond the joint. This incision divides the skin and cellular tissue. The edge of the bistouri now divides the rest of the soft parts in a direction from before backwards, to the articulation. The edge is then turned to the side of the joint, which it lays open, and traverses to the opposite side, dividing both the flexor and extensor tendons. This step is facilitated by carrying the finger in a direction opposite to that on which the incision has been made; while the assistant must be careful to keep the skin retracted towards the wrist. The corresponding flap is then formed on the opposite side, by cutting from the joint to the commissure, the knife grazing the bone of the extirpated finger on its passage from within, outwards.

This is an improvement, by Lisfranc, upon the plan of Petit and Ledran. Sharpe employed the circular method, which has since been unnecessarily revived by M. Cornuau.

The object of prolonging the incision beyond the joint, both on the palmar and dorsal surfaces, is that it enables the operator to divide all the fibrous tissues around the joint, without wounding the lips of the wound, and give a cleaner surface to the incisions ; and he may save himself any embarrassment arising from the necessity of seeking for the joint, by drawing the finger firmly in the manner directed. Some surgeons think it better to make the incisions fall, not exactly on the centre of the interdigital commissure, but a few lines beyond ; but unless the soft parts be very scanty, this rule need not be attended to : when these are abundant, the excess of skin would be liable to pucker, and impede the cicatrization by becoming turned upon itself. When the soft parts are cut close to the bone, the digital arteries alone will have been divided, the trunk remaining untouched. If the hæmorrhage should not cease by the coaptation and compression of the flaps, these two vessels may be twisted or tied.

Dupuytren, supposing that the anterior end of the metacarpal bone would, from its size, produce deformity and inconvenience, recommended the removal of the finger by sawing the bone above the joint. But the idea is an erroneous one, and has not been adopted.

Petit's plan was to make both the incisions from without, inwards, or from the commissures to the joint, the joint being cut through by a transverse incision. The flaps by this method were more regular, but the modern method is by far more prompt.

Oval method.—The preliminary arrangements are the same as in the preceding mode. The surgeon commences his incision as before, three lines beyond the dorsal surface of the articulation, carrying it to the centre of the commissure, on dividing which the edge of the knife is carried along the transverse palmar line, that marks the junction of the finger with the palm of the hand, to the opposite side of the finger, from which point it is again carried up obliquely to the back of the metacarpus, till it joins the commencement of the first incision. He now draws the finger towards himself, and thus widening the lips of the wound as much possible, he cuts the extensor tendon, lateral, and palmar ligaments ; then bending the finger still more, he forms the flap by terminating his incision at the palmar line, over which the knife had already passed.

In the flap method, the lateral flaps cover the bone in its large diameter, which is antero-posterior (fig. 10). In the oval method, the flap is taken entirely from the palmar surface of the extirpated finger, and when not cut too long or too broad, fits the exposed surface easily and well. But it does seem as if carrying the incision along the palmar line of the finger in the first instance was altogether superfluous, seeing that when the head of the phalanx is disarticulated, the incision which completes the operation, by forming the flap, must terminate there. Another point in its favour is, that it does not require, as the former mode, to have any incision carried into the palm of the hand. It is, however, not so easily performed, and should not be attempted without that familiarity with the parts which frequent trials on the dead subject can alone give.

This plan is also applicable where more than one, or even all the fingers are to be amputated.

AMPUTATION OF THE FOUR FINGERS TOGETHER.

This amputation, which had been mentioned in some of the old works on military surgery, was first methodically described by Lisfranc, to whom we are indebted for finally establishing it as an advantageous operation. It is but an application to all the fingers of the hand, of the process described above, for a single finger. The hand being placed in pronation, the surgeon takes hold of the fingers in his left hand, his thumb and index finger holding the little finger close to the joint if it be the right hand, the index finger if it be the left. An assistant retracts the skin, and the surgeon commences his incision about three lines lower than the joint, with a convexity towards the fingers, carrying it across the back of the articulations, from one side of the hand to the other (*g*, *l*, or *g*, *m*, fig. 12). By this incision, the extensor tendons are laid bare ; the assistant opens the wound by the retraction, and the flap is dissected a little, till the joints are exposed ; the tendons are then cut on a level with the joints, and the lateral and palmar ligaments of each are divided in succession with the point of the knife. He now passes the blade in front of each phalanx, which he raises, one after the other, and forms his flap by following the palmar fold which separates the fingers from the palm of the hand.

When any of the fingers can be spared, care should be taken to protect them from being wounded by the bistouri. This object may be facilitated, by cutting on the palmar lines, in the first instance, to form the thick flap, then dissecting the dorsal one, and, lastly, opening the joints in succession from left to right.

Before the age of fifteen or sixteen, the ossification of the heads of the metacarpal bones being incomplete, they may be easily cut with the knife. This disposition will allow of the removal of the heads of the bones themselves, without any disarticulation of the fingers, and besides, give a larger flap.

The circular method, recommended by M. Cornuau for a single finger, is also employed by him and others for the removal of the entire. He first forms the palmar flap along the directing line into the articulations ; he then forms the dorsal flap across the back of the fingers, a little above their commissures, dissecting up, and penetrating into the articulations; each phalanx is then disarticulated in succession.

Fig. 11.

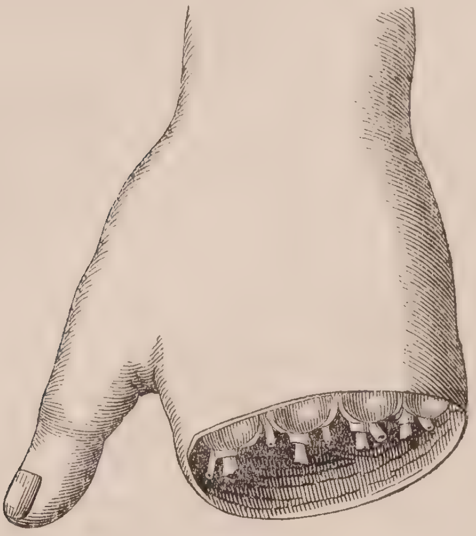

Fig. 11 *represents the amputation of the four fingers in their articulations with the bones of the hand; the ends of the metacarpals, with the divided tendons and blood-vessels are seen at the bottom of the wound.*

When the trunk of the digital arteries is not divided, the hæmorrhage will be slight, and easily commanded by compressive dressing. Should any ligatures be necessary, they should be carried out at the inferior or cubital angle of the wound. The lips of the wound are united by straps of diachylon or isinglass plaster. The continuation of the flexor tendons by sheaths, through the palm of the hand, and the loose cellular tracks having the same direction, make it a point of the utmost importance to take proper precautions against the propagation of suppuration upwards towards the wrist and fore-arm. The dressings in these cases must not be confined to the wound alone, but must include the palm of the hand also. Compresses should be placed judiciously, so as to prevent the fusing of pus upwards, and these should be secured by a roller, which will be made to come down from the fore-arm and wrist.

If inflammation should arise, the stump must be covered with leeches and poultice; and if, in spite of these means, pus is formed higher up, there is no time to be lost; deep and free incisions must be made to give it ready exit wherever it is found collected. The remedy is a severe one; but there is often no alternative but another amputation, or the loss of life itself.

METACARPUS.

The bones of the metacarpus may be amputated singly, or the four that support the fingers may be removed at once, each or all of the fingers which they support being extirpated with them. The operation may be performed, either in the continuity of the bones, or at the carpo-metacarpal articulations. Portions of them may also be resected; they may even be extirpated without entailing the loss of the finger with which they are continuous.

Fig. 12.

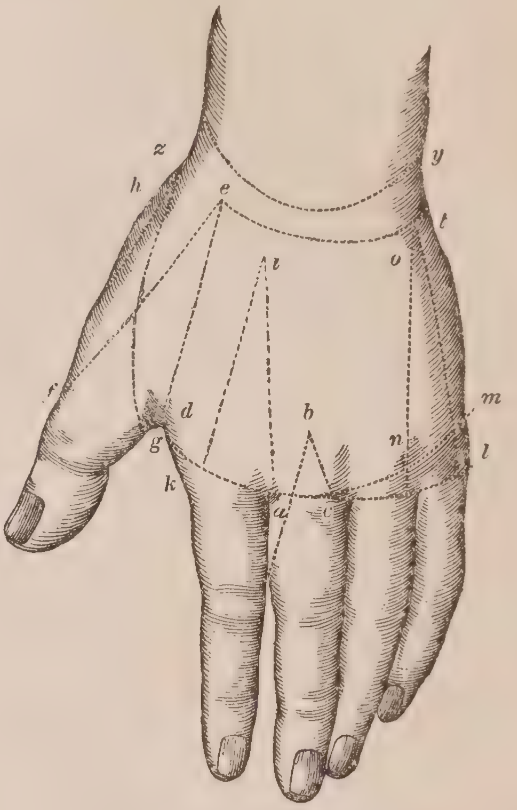

Fig. 12 *represents the lines of incision for the circular, flap, and oval methods of amputating the hand, either partially or totally: a, b, c, the two dorsal incisions in the oval amputation of the middle finger in its articulation with the metatarsal bone; the incision on the palmar surface runs in the digito-palmar line, and cannot be seen in this view; d, e, f, disarticulation of the thumb from the trapezium,* (see fig. 14,) *by the flap method; g, h, f, disarticulation of the thumb by the oval method* (fig. 16)*: the digito-palmar incision between g, f, is not seen; k, i, a, oval method applied to the disarticulation of the metacarpal of the index-finger, from the carpus: the incision in digito-palmar line not seen; n, o, l, the two dorsal incisions in the oval method for amputating the metacarpal of the little finger. The incision in the digito-palmar line, and which unites their extremities, is not seen; m, g, or l, g, the dorsal incision for the amputation of the four fingers together,* (see fig. 11); *e, t, prolonged to z, dorsal incision in the amputation of metacarpals at the carpus; y, z, dorsal incision for amputating in the wrist-joint.*

Amputation of a single metacarpal bone in the continuity.—The hand being held in pronation, the surgeon transfixes it with a narrow and well pointed bistouri, from the dorsal to the palmar side, a few lines above the diseased or injured part. The point of the knife keeps close to the bone as it passes, the skin is drawn to one side, and the incision is directed along the edge of the bone, till it comes out at the corresponding commissure of the fingers. The soft parts covering the untouched side of the bone are drawn from it by the left thumb and fingers of the surgeon or his assistant; the point of the knife is again inserted at the top of the wound, but at the opposite side of the bone, and the soft parts being drawn off from it, the second incision falls into the same line, dividing them again down to the commissure of the other side of the finger. The point of the bistouri is used to make a track for the saw, clearing the bone at that part, of any shred of muscle, &c., that may remain attached. A small plate of wood or pasteboard is then introduced on one side of the bone, and a small saw at the other. The bone is then sawed in bevel or splice. Velpeau recommends the bone to be bevelled towards the ulnar side for the two last fingers, and towards the radial side for the two first. The index, middle, and ring-finger, are the best suited for amputation in the continuity.

Fig. 13.

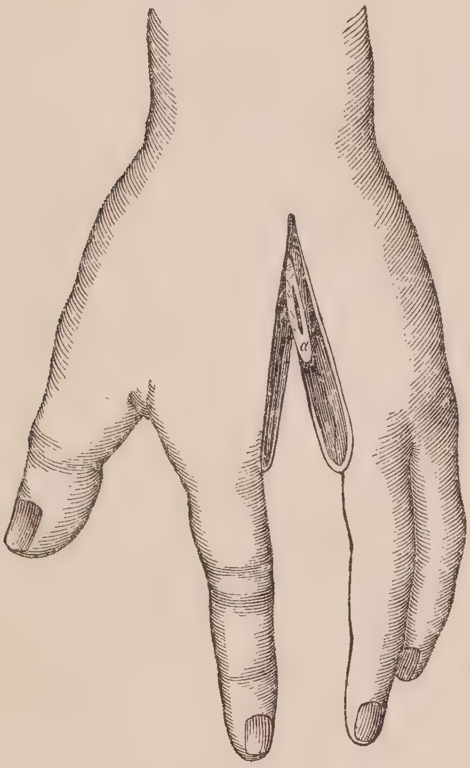

Fig. 13 *represents the amputation of the middle metacarpal; the bone, a, is cut in splice to allow the better coaptation of the sides of the wound. The deformity is scarcely perceptible after an amputation of this kind.*

The hæmorrhage may arise, either from the digital arteries, or from their trunk; when from the latter, the two divided extremities may require to be tied. In general, however, the coaptation of the lips of the wound, with even gentle compression, will be sufficient to arrest the bleeding.

Louis, in the case of a young girl, sawed off all the metacarpal bones at the middle. A flap with a semilunar edge towards the fingers was formed on the back of the hand; another in the palm, by passing a narrow bistouri, flat and close to the bones from one side of the hand to the other, and cutting downwards to the proper extent; the interosseous spaces were then cleared with the point of the knife for the saw, which was applied to each of the bones in succession.

AMPUTATION OF THE METACARPAL BONES IN THE CONTIGUITY.

Amputation of the thumb.—The thumb on its dorsal surface is so bare, that the articulation of the metacarpal bone with the trapezium may be easily felt, especially by bringing it close to the index finger. The articulation itself is separated from that of the index finger by a small bony projection from the trapezium. The joint formed between these two bones, a sort of arthrodial ginglimus with loose ligaments, is slightly concave from without inwards, with an oblique direction which corresponds with a line drawn from its outside, towards the root of the little finger.

Although there could be no impropriety in amputating the anterior part of the metacarpal bone of the thumb in the continuity, if the disease was confined to it, still its mobility is so extensive that its disarticulation is most commonly preferred, on account of the great facility with which it may be effected, and by whatever method the surgeon may think proper to adopt.

With one flap.—The hand being in pronation, the thumb is abducted from the fingers; the soft parts are retracted by an assistant. The surgeon applies the edge of the bistouri, with its point upwards, against the centre of the commissure, and striking at once towards the ulnar side of the bone, guides himself by it till he reaches the carpus (*g*, *e*, fig. 12). The incision is still further prolonged to the extent of five or six lines, both on the dorsal and palmar surfaces, in order to give greater facility for disarticulating the head of the bone from the trapezium. If the knife has not been kept close to the bone, it may reach the carpus on the other side of the little bony tubercle of the trapezium, and, in that case, the operator will be puzzled to open the joint. This difficulty will be avoided by making the incision in the manner described. The joint is opened by inclining the edge of the bistouri outwards, and all the ligaments are divided with its point. The head of the bone being now freed, the edge of the knife is brought out, and an external flap is formed by keeping as close to the bone as possible (*e*, *f*). The quantity of soft parts preserved will be still more considerable, if care be taken, in making the first incision, to incline the edge of the knife towards the ulnar side of the hand. The second incision is carried a few lines lower than the metacarpo-digital articulation.

Fig. 14.

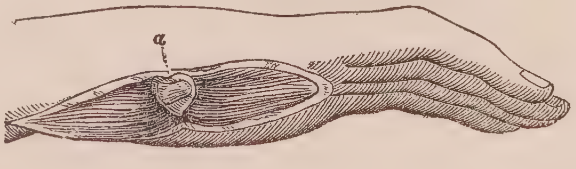

Fig. 14 *represents the amputation of the thumb with a single flap: the flap is thrown back against the side of the wrist: a, marks the articular head of the trapezium.*

If the radial artery has been divided, it will be found at the upper end of the second metacarpal bone, where it may be tied; if it has not been touched, the other small dorsal arteries of the thumb will, in general, cease to bleed upon the coaptation of the lips of the wound. It will be necessary to make use of a compress, after the adhesive straps are applied, in order to support the flap somewhat firmly against the second metacarpal bone.

Velpeau has often amputated, by making a dorsal incision from the styloid process of the radius to the middle of the commissure, and dividing at once the skin, extensor tendon, and a portion of the first interosseous muscle. The joint is thus laid bare at the first stroke. The assistant separates the lips of the wound; the articular ligaments are divided with the point of the knife, and the head of the bone being now luxated, the knife is carried under it, and the operation terminated by cutting outwards along its surface.

Fig. 15.

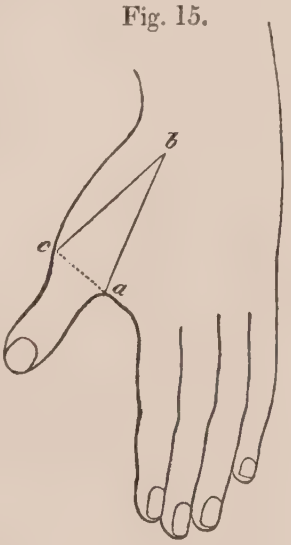

Fig. 15. *c, b, a, show the lines of incision for performing the amputation of the thumb by the oval method; the dotted lines, c, a, show the course of the incision by which their extremities are united on the palmar surface.*

The oval method is particularly well suited for this amputation. A dorsal incision, beginning a little above the articulation with the trapezium, is carried down till it terminates on the ulnar side of the first phalanx of the thumb (*b, a*). At this stroke the bone is laid bare. The hand is then put in supination, and the incision is continued round the root of the thumb, in the digito-palmar line (*c, a*), and is thus brought up (*c, b*) till it joins the commencement of the first incision. The articulation is then laid open, and all its ligaments divided with the point of the bistouri. The soft parts still adhering to the bone are then detached, by the knife being carried down till it joins the incision of the palmar line.

Fig. 16.

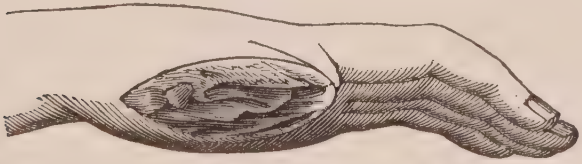

Fig. 16 *represents the flaps resulting from the oval method: the bone is seen at the upper angle of the wound.*

The oval, as a general method, is perhaps the best for this particular amputation. The cicatrix is linear, and the adhesion takes place with remarkable rapidity. But it is not so promptly performed as the amputation by flap, and it requires greater dexterity on the part of the operator.

When the metacarpal bone alone is diseased, modern surgeons have been successful in extracting the necrosed or carious bone, without involving the phalanges in the ablation. The process by which this is effected is not, strictly speaking, an amputation, but a resection; to which head the reader is referred for a description of the mode of performing it.

Metacarpal bone of the little finger.—Flap method.—This bone is united at its carpal extremity to the next metacarpal bone by a plane articular surface, protected by ligamentous bands; it also shares with it its articulation to the unciform bone. It may be discovered on the dorsal surface, by inclining it outwards, and feeling for the slight depression which corresponds with the articular interline, just in front of the pisiform bone.

This amputation may be commenced, either by first forming the external flap, or the flap may be formed in terminating the operation. If the surgeon prefers forming the flap first, the assistant draws the soft parts away from the back and palm of the hand, in order to preserve as much of the hypothenar eminence as possible. The bistouri is passed through on a level with the carpo-metacarpal articulation, and made to glide along the ulnar side of the bone till it arrives two lines lower than the commissure between the little and middle fingers, where the incision terminates (*t, l*). The little finger is then separated as much as possible from the ring-finger, and the edge of the knife is carried rapidly through the commissure, up the radial side of the bone (*n, o*), till it reaches the opposite side of the joint, enlarging the upper angle of the incision, by pressing the point of the knife on the dorsal and the heel on the palmar side of it. Some surgeons (among whom Lisfranc,) begin the second incision opposite the commencement of the first; the soft parts are so drawn away from the bone towards the radial side of the hand, that the point of the knife may easily be made to penetrate through the interosseous space, without again wounding the skin. The soft parts are then divided with a sweeping cut, which runs along the radial side of the bone, and terminates at the interdigital commissure. The ligaments of the articulations are then divided with the point of the bistouri, either from within outwards, or from without inwards, following the dorsal line, and the head of the bone is luxated, and at once removed. The steps of the operation may be reversed; but being essentially the same, it is unnecessary to go over the description again.

Fig. 17.

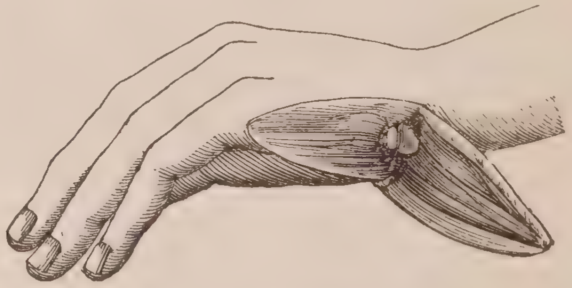

Fig. 17 *represents the amputation of the little finger with a single flap: the two articular surfaces, from which the head of the metacarpal has been removed, are seen at the upper angle of the wound.*

The oval method has been employed for this amputation by M. Scoutetten. The mode of performing is as follows: the hand being thrown into deep pronation, the surgeon begins an incision a little above the articulation, carrying it down in a straight line to the ulnar edge of the first phalanx (*t*, *l*, fig. 12); the edge of the knife then follows in the line which separates the finger from the palm of the hand, till it ascends between the little and ring-fingers, to join the first incision at an acute angle, (*n*, *o*). The soft parts are then dissected from the bone, and the ligaments divided in the manner already described. This operation cannot be executed with the same promptitude as the other, but it leaves only a linear cicatrix.

Amputation of the index, middle, or ring-finger, in the carpo-metacarpal articulation.—On inspecting the manner in which the heads of these three bones are so closely locked in, it will be obvious that the amputation of any one of them must be much more difficult than that of either of the two bones, we have been describing. That able operator, Langenbeck, however, recommends their removal, and performs the operation by the oval method. He begins his incision about half an inch above the articulation, carrying it down the dorsal surface, along the side of the bone, and turning the edge of the knife round the base of the finger in the palmar line, continues it upwards again on the back of the hand, and on the opposite side of the bone, till he reaches the point from which he first started. The interosseous, and articular ligaments are next to be divided with the point of the knife, gently, and without using any violence. This step of the operation is the most tedious, and will vary according to the bone to be removed. The form of the articulation should be carefully examined on the skeleton before the operation. The wood-cut accompanying the text will also help the memory. The assistant throws the lips of the wound as wide asunder as possible, and thus affords all proper help to the surgeon in his efforts to luxate the head of the bone. As soon as he succeeds in this, the knife, held flat, divides the parts in front of the bone, up to the commencement of the finger, where it falls into the incision of the palmar line. The cicatrix left is linear.

The operation may also be performed by commencing at the commissures, carrying the incisions upwards, at each side of the bone in succession, and luxating the head of the bone in the manner already described.

Simultaneous amputation of the four metacarpal bones supporting the fingers.—The mode in which the first and fifth metacarpal bones are articulated having been already described, we have now only to review that in which the other three metacarpals are connected with the bones of the carpus, and with each other. The space between the metacarpal of the index finger, and that of the thumb being large, their connexion may be said to be one of mere juxtaposition; its connexion with the middle metacarpal, on the other side, is intimate and strong; and a tubercle, of several lines in length, ascends with a like prolongation from the middle metacarpal, both wedging or imbedding themselves upon an indentation, which they make, respectively, on the two carpal bones, the trapezoid, and magnum. Their tubercles give insertion to two strong tendons. The second metacarpal is articulated with the trapezoid and the magnum; the middle metacarpal articulates in an oblique line, the direction of which is outwards, with the magnum; while the fourth articulates transversely in part with the magnum, and in part with the unciform, the articular surface of which it shares with the metacarpal of the little finger.

Fig. 18.

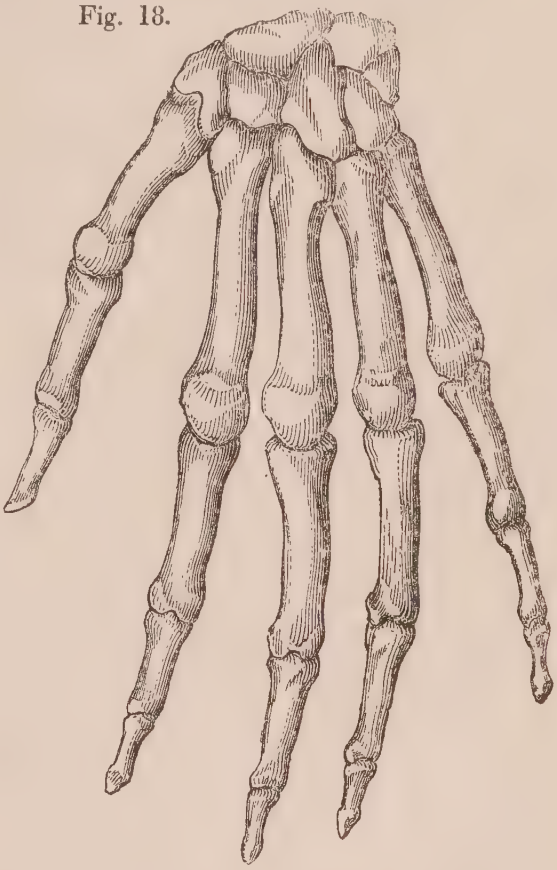

Fig. 18 *represents the skeleton of a hand with the forms of the articulations, and the courses of the articular interlines of the carpus.*

Though the whole line of these articulations is transverse, yet it is very irregular. To follow it from the thumb to the little finger, on the dorsal surface, (see skeleton of the hand, fig. 18.) we observe that of the thumb is directed obliquely forwards and inwards, and that it stops one or two lines further forwards than that of the index finger. The articular interline of the second proceeds, first, in a direction obliquely backwards, then transversely in front of the trapezoid, and then obliquely backwards again, to turn the tubercular prolongation. It then comes again obliquely forwards; continuing in this direction in front of the magnum, it reaches the fourth metacarpal, from which it passes in front of the unciform almost transversely.

All these bones are strongly bound together by dorsal and palmar ligaments extending from one to another in various directions. Their synovial lining is continuous with that of the bones of the carpus; on which account, inflammation arising after amputation may be attended with serious consequences.

Mode of performing the amputation.—An assistant commands the circulation in the radial and ulnar arteries; the hand being in pronation, the surgeon takes hold of the four fingers, and forms a dorsal flap, with a convexity towards the fingers, a little more than half an inch in front of the articulations, beginning the incision on the radial, or ulnar side, according as he may have to remove the right or left hand, and carrying it quite across the back of it (*t*, *e*, *z*, fig. 12). The skin being retracted, the extensor tendons are divided on a level with the joints, and the surgeon, with the point of the knife, follows the line described above (fig. 18), laying open the backs of the articulations, but without making any attempt to penetrate into them. When they are all divided, he presses with a certain degree of force on the hand, and luxates the bones; he now completes the division of the ligaments, and getting the knife on the flat, on the palmar surfaces of the bones, carves a semilunar flap of an inch or an inch and a half in length, by carrying it forwards and outwards.

This process may be reversed, by first forming the palmar flap, then the dorsal, and luxating the bones in the manner already described.

If only one or two of the metacarpals are to be removed, the method will then present a combination of the transverse dorsal and palmar incisions over the bones to be extirpated, and one or two longitudinal ones, as the case may be, beginning at the interdigital commissure, and ending at the head of the bone, to isolate them from those that are spared.

As a general rule, the amputation of the bones of the metacarpus, ought to be preferred to that of the wrist, when the disease or injury demanding it, does not extend to the carpus. This precept, however, is not laid down by systematic writers on surgery, nor has it been followed to so great an extent as it deserves, since it was first proposed. It is unquestionably an immense advantage to preserve a moveable portion of the member beyond the wrist joint. Since the idea was first broached at the beginning of the present century, the operation has been performed with success by Guthrie, Sully, Walther, Gensoul of Lyons, Troccon, and many others. In several cases on record, surgeons have not confined themselves, in these partial amputations of the hand, to the ablation of the metacarpal bones only, but have, at the same time, when circumstances required it, removed even one or more of the first range of the carpal bones.

Whenever the thumb is not irretrievably involved in the disease, the surgeon should make an effort to preserve it, as the variety and extent of its movements make it still capable of executing many of the functions of the hand.

All these operations require exact anatomical knowledge, and considerable dexterity on the part of the operator. He who has not acquired facility of execution by frequent trials on the dead subject, should be cautious in undertaking an operation, which, though simple, may embarrass him.

WRIST JOINT.

Of the four bones in the second or upper range of the carpus, three only enter into the composition of the wrist-joint; these, counting from the thumb, are the scaphoid, the lunar, and the cuneiform. Together, they form a long oval, with a polished convex surface, which is received into an articular hollow of similar form, and concave also from front to back, prepared for it in the conjoined extremities of the two bones of the fore-arm, the radius and ulna. The styloid processes of these two bones are readily distinguished; the articulation is placed a little below them.

The transverse lines on the palmar surface of the wrist, immediately above the palm of the hand, will serve as guides to the articulation. The first of these lines corresponds to the interline that runs between the two rows of the bones of the carpus; the second, which is nearly half an inch higher, corresponds to the wrist-joint. Sometimes a third line is seen still higher up the fore-arm, which points out the extent of the epiphyses of the bones. Malgaigne furnishes other data for recognizing accurately the position of the joint. If the hand be bent strongly back, the summit of the angle, which it will thus form with the fore-arm, will correspond with the articulation.

Amputation of the hand at the wrist.—This operation is specially applicable, and, indeed, the most proper to be resorted to in those diseases which have spared the articulation of the wrist, and the soft parts surrounding it. The great success that has hitherto attended it has not, as yet, obtained for this mode the preference it is entitled to, over amputations in the continuity of the fore-arm; and many surgeons still resort to the latter, notwithstanding the encouraging results obtained by surgeons of the highest merit. It is performed, either by the circular, or the flap method.

Circular method.—An assistant retracts the skin, and commands the circulation in the radial and ulnar arteries. The surgeon commences his incision, either on the dorsal or the palmar surface; if on the latter, the edge of the knife runs in the line immediately above the thenar and hypothenar eminences. On reaching the upper part of the thumb, he turns the patient's hand, first semi-prone, then prone, carrying the edge of the knife across the back of the wrist, thus completing the circle. The skin being dissected back, and again retracted, the tendons are divided, and the knife enters the joint, either on the radial or ulnar side, guided by the styloid process; the section of the capsular ligaments is completed, by cutting in a curved line from one side to the other.

The line in which the incision is traced leaves the pisiform bone on its palmar side, so that the operator cannot be embarrassed by it.

Flap method.—The old method of performing this amputation was to form two flaps, which may be accomplished in two ways :—

First,—The hand in pronation, a semilunar incision, extending from one styloid process to the other, with the convexity towards the fingers, carried across the hand, forms a dorsal flap (*z*, *y*, fig. 12). This is dissected up to the joint, the dorsal and lateral ligaments are cut through, and the joint is laid open, the carpus is luxated, the knife on the flat gets in front of the carpal bones, and a sufficient palmar flap is formed. It will be necessary to raise the knife at the side of the pisiform bone, to avoid including it in the flap.

Second,—The hand in semipronation, the surgeon passes a slender double-edged knife on the flat, across the front of the joint, from the styloid process on one side, to the same point on the other. Before penetrating with the knife, he relaxes the soft parts, as much as possible, by bending the hand on the fore-arm ; the protuberances of the scaphoid and pisiform bones are avoided by elevating the edge of the knife at these points : the hand is then extended, so as to level the soft parts, and make the flap more regular, and the knife is carried out, the surgeon cutting towards himself ; or the flap may be formed, by carrying the handle of the knife in a circular sweep from one side of the hand to the other, in such a manner as to form a long semicircular flap out of the palm.

The hand is then turned into pronation, and another semicircular dorsal flap is formed, and dissected upwards as high as the joint. The hand is then put into the semiprone position, and the edge of the knife, entering at the styloid process, makes a clear section of all the ligaments, and separates the hand from the forearm.

This plan is more prompt and brilliant than the preceding one ; but the results of either of these plans are not so advantageous as those of the circular method, which consequently deserves the preference.

A single flap, taken from the palm of the hand will afford a sufficient covering, when the soft parts on the back of the hand are unfit to form a second flap. In such a case, it should be more ample in order to compensate for the want of the dorsal flap. It is unnecessary to repeat the directions for forming it.

The arteries to be tied or twisted are the radial and the ulnar ; the hæmorrhage will often be arrested by compression alone. The interosseous artery is too small to require any particular attention.

Fig. 19.

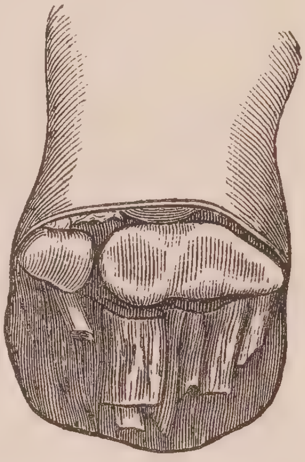

Fig. 19. *Amputation at the wrist-joint, with a single flap, formed from the soft parts of the palm of the hand, the hand itself in pronation; the articular ends of the radius and ulna, with the tendons of the flexor muscles of the fore-arm, are seen in the wound.*

Fig. 20.

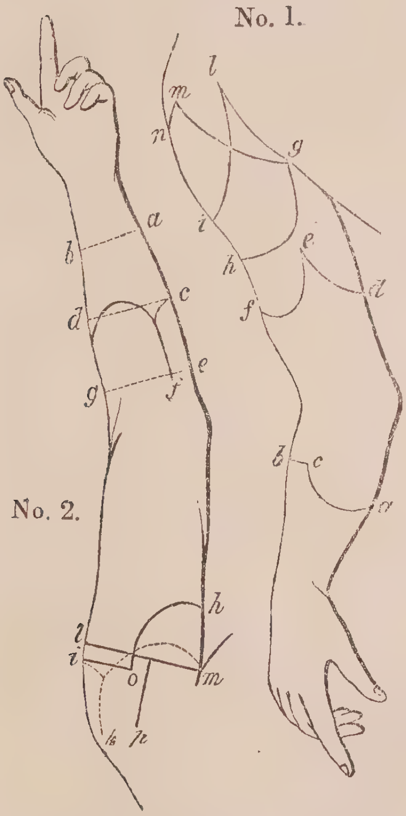

Fig. 20. *Front view of the arm and fore-arm, representing the lines of incision for amputations of the superior extremity, by the circular, flap, and oval methods. No.* 1, *b*, *c*, *a*, *single flap, fore-arm ; f*, *e*, *d*, *double flap at the lower part of the arm ; h*, *g*, *single flap from the outside of the upper part of the arm ; i*, *l*, *g*, *an external and internal flap for amputation of the arm at the shoulder-joint ; n*, *m*, *g*, *two oblique incisions, Guthrie's or Velpeau's method for the same.*

No. 2. *a*, *b*, *circular of the fore-arm ; d*, *c*, *the same higher up ; c*, *f*, *d*, *double flap in the thick of the fore-arm,—a portion only of the line of the external flap is visible ; g*, *e*, *circular incision for amputation at the elbow-joint ; i*, *o*, *h*, *a single flap from the inside of the arm,—circular and perpendicular incisions, or double flap, according to Hesselbach, for amputation at the shoulder-joint ; i*, *k*, *m*, *an anterior and posterior flap for the same disarticulation (Dupuytren).*

Fig. 21.

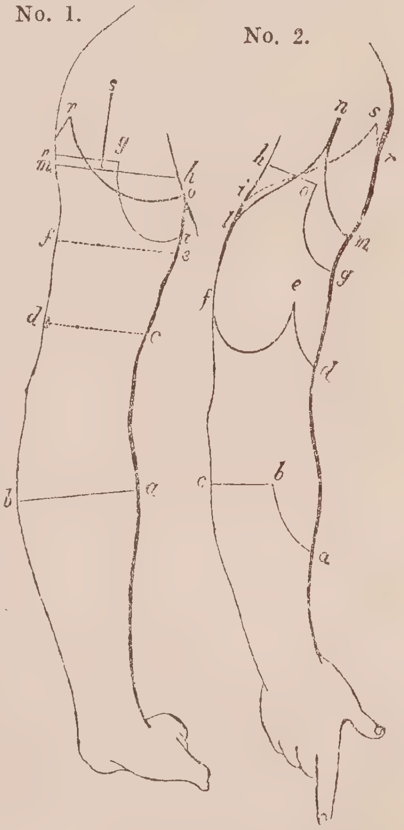

Fig. 21 *represents in lines, the various incisions made in the circular, flap, and oval methods of amputating on the fore-arm, arm, and shoulder.*

No. 1, *back view: a*, *b*, *circular method on the fore-arm ; d*, *c*, *on the lower part of the arm ; f*, *e*, *middle of the arm ; n*, *g*, *i*, *single flap on the upper part of the arm ; m*, *h*, *s*, *disarticulation of the humerus, by the double flap, according to Hesselbach's plan ; r*, *o*, *Larrey's improved plan, a double flap, anterior, and posterior.*

No. 2, *back view, c*, *b*, *a*, *single flap, from the soft parts on the front of the fore-arm ; f*, *e*, *d*, *double flap at the middle of the arm ; h*, *o*, *g*, *amputation of the humerus, a single external flap ; l*, *m*, *n*, *disarticulation of the humerus by two flaps, according to Dupuytren's plan ; i*, *s*, *r*, *disarticulation with two flaps, Guthrie's plan.*

FORE-ARM.

Amputation of the fore-arm in its continuity.—Notwithstanding that the contrary opinion has been avowed by respectable authority, the general rule of removing as little as possible in amputations of the thoracic limb, is as applicable to the fore-arm as to any other part of the superior extremity. It is quite true, that the muscles, which are thick and full at its upper part, become gradually thinner, and more tendinous, towards its inferior third; but this change does not prevent the formation of a good stump, and there may be always a sufficiency of skin, the staple, generally speaking, of a good cicatrix, to cover the bones, tendons, &c. In this amputation, the circular, flap, and oval methods, are all equally applicable.

Circular method.—For this operation a slender bladed catling, and a three-tailed retractor will be required. There should be also two or three assistants; one to command the circulation, by compressing the brachial artery with his fingers against the inside of the humerus, or with a *garrot* and pad; another to support the diseased hand enveloped in a piece of linen; and a third, if he should be required, to hold the fore-arm, and be ready, as soon as the circular incision is made, to retract the skin. The fore-arm is presented in pronation, the surgeon takes hold of it above the place where he is about to cut, if it be the left arm—below, if it should be the right, and makes an incision all round, which will lay bare the fascia; the assistant retracts the skin to the extent of about an inch, or an inch and a half, the surgeon assisting him, by rapidly dividing the small fibrous bridles, wherever they impede the retraction. Another circular incision divides the muscles to the bone; these retract, and the knife is used to divide the interosseous muscular fibres, both on the front and back of the bones, together with the ligament extended between them. If the patient be very young, the knife used for this purpose must be slender. The retractor is then applied, the middle tail between the radius and ulna, and the muscles are thus drawn back and protected. We must not trust too much to the retraction of the muscles for forming a good stump; it should be borne in mind, that the muscles here are, for the most part, closely adherent to the bones. It is, therefore, highly important to preserve sufficient skin and muscle, without any reference to what may be gained by retraction. When a difficulty is found in dividing the muscles and tendons in the interosseous spaces, Cloquet directs the knife to be passed on the flat between them and the bones, and then turning the edge, to divide them transversely from within outwards. The periosteum being carefully cut along the track in which the bones are to be sawed, the surgeon commences sawing the bones, first on the radius, and then on the ulna, so as to saw both together. The radius ought to be sawed completely through before the ulna; as the latter, from being more largely articulated with the humerus, will serve to support it. Malgaigne recommends the middle position, between pronation and supination, for sawing the bones, in order that they may be divided on the same level with the muscles; for if the bone was sawn in pronation, the radius would project beyond the ulna in supination, and *vice versâ.*

Fig. 22.

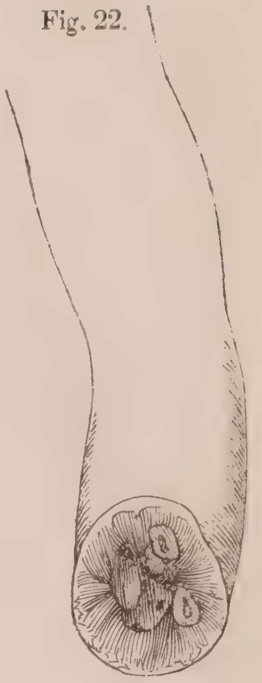

Fig. 22. *Circular amputation of the fore-arm* (*a*, *b*, no. 1, fig. 20); *the radius and ulna are seen, the one above the other, the fore-arm being semi-prone.*

The retractor is then taken off, and the two arteries sought for: the interosseous will seldom require a ligature. In tying the vessels, they should be carefully isolated from their accompanying nerves. The line of reunion must be the same as that of the bones.

Flap method.—Græfe performs this operation by forming a single flap from the anterior surface of the fore-arm. His mode of proceeding is as follows:—a thin knife is passed from side to side in the front of the bones, and a semi-elliptic flap is formed; the skin and muscles of the posterior surface are divided down to the bone by a semicircular transverse incision (*c*, *b*, *a*, no. 1, fig. 20). The soft parts are then retracted, and the bones are sawed in the usual way.

The plan with two flaps is preferred to it, and is performed, according to Vermale's method, at any part of the fore-arm. The fore-arm being in the middle state between pronation and supination, the anterior flap is formed first. The strongest objection to this plan arises from the liability of the two ends of the bones to protrude at the corner of the wound; an objection from which the circular method is free. It may, however, be observed, that

Fig. 23.

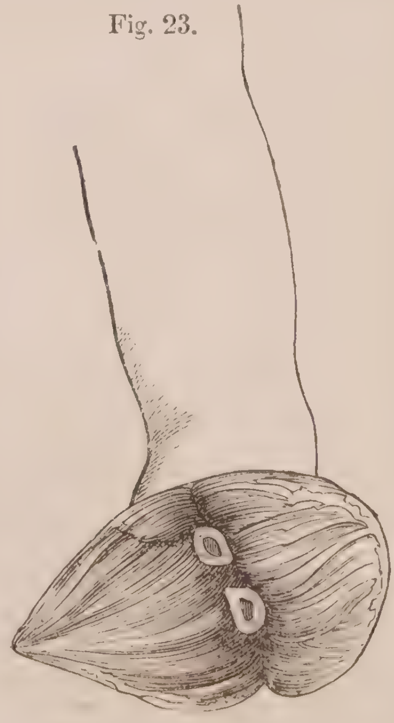

Fig. 23. *Double flap amputation of the fore-arm.*

though the circular be the best, as a general method, the other plans will be often of great value in particular cases.

ELBOW-JOINT.

Amputation of the fore-arm at the elbow-joint.—The objection to amputating in an extensive articulation, and the difficulty attaching to the performance of the operation are deemed, very generally, a sufficient reason for preferring the amputation in the continuity of the lower third of the humerus, to the ablation of the fore-arm, by penetrating into the joint. Setting, however, these considerations aside, we are ready to acknowledge, that it is a great advantage to save the lower third of the humerus; and that the operation has been attended with a fair average of success.

The precise situation of the joint is readily ascertained, by the lateral prominences of the three bones that form it. In front, the heads of the radius and ulna are nearly on the same level, and form a transverse line, interrupted only by the slight elevation of the coronoid process of the ulna; and hence the facility of carrying the edge of the knife, at one stroke, into the joint. The operation may be performed either by the circular or flap method.

With a single flap.—The fore-arm being in supination, and slightly bent, a long, slender, double-edged knife is passed on the flat, close to the bones and in front of the joint, transversely, beginning at the ulnar side, from a little below the tuberosity of the humerus on one side to the same point on the other; the edge of the knife being downwards, a flap is formed of about three inches in length, by cutting obliquely downwards and outwards. Another transverse incision, extending from one angle of the base of the flap to the same point on the opposite side, completes, by a semicircular sweep, the division of the skin and muscles at the back of the joint. The anterior flap is retracted, the knife enters the articulation between the radius and humerus, cutting the external lateral ligament, and disarticulating the radius; the point of the knife is then applied to the ligaments that connect the ulna and humerus; those of the olecranon are most accessible at the back of the joint.

Fig. 24.

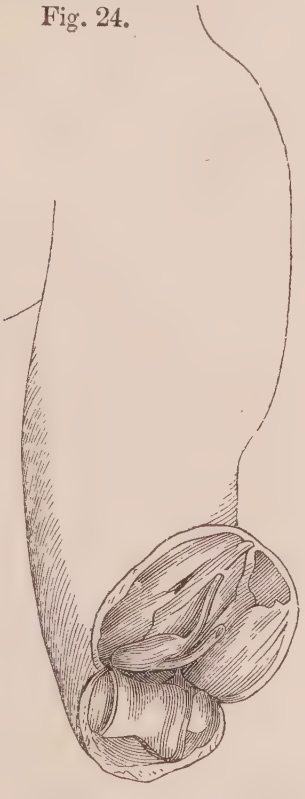

Fig. 24. *Flap amputation of the fore-arm at the elbow-joint, the flap taken from the soft parts on the front of the fore-arm; the articular surfaces of the humerus are seen at the back part of the wound.*

Dupuytren, in some cases, used to saw off the olecranon, although it does not appear that he had any very decided motive, either for adopting or omitting that step. It is quite certain that the triceps will still have the power of moving the arm after the olecranon is removed. Its removal gives more regularity to the stump, while it also diminishes the extent of the wound. The saw may be made to attack it, either from front or back. Brasdor used to form the posterior flap first.

Velpeau's plan combines the features of an amputation in the continuity and in the contiguity, as he removes the coronoid and olecranon processes of the ulna with the saw. In this way the operation is freed from the difficulties encountered in the disarticulation of the ulna, and the extent of wound is lessened.

Circular method.—The surgeon, standing on the outside of the arm, makes a circular incision, from an inch and a half to two inches below the joint, cutting down to the fascia; he then dissects the skin with its adipose membrane up to the level of the articulation. It is then retracted, or turned back by an assistant, and the muscles are cut down to the bones. The lateral ligaments are cut, and the bones are disarticulated, by pulling the fore-arm downwards; the point of the knife is made to turn round the olecranon, and the tendon of the triceps attached to it is cut through.

Velpeau gives a decided preference to the circular method in amputation of the fore-arm at the elbow-joint. In regard to the ligature of the arteries, it makes this difference—that there is but one to tie, the brachial; whereas, in the flap method, where the muscles are cut for three or four inches down the fore-arm, this artery is cut below its bifurcation. The wound which is made chiefly on cutaneous parts will also be more disposed to speedy union and less to suppuration.

THE ARM.

The humerus is a single bone, enveloped on all sides with muscles, except at its lower part. These muscles may be classed in three series: those that come from the trunk to be inserted into it; those that lie upon it without adhering to; and those that cover and adhere to it. The first are inserted into the upper part of the bone; the second into the fore-arm, and the last belong more strictly to the humerus itself.

Larrey objects, but seemingly without sufficient grounds, to amputation being performed at the upper part of the bone, preferring its total extirpation by amputating in the articulation itself. When the large muscles of the trunk are divided in amputating above the insertion of the deltoid, they certainly do retract to a considerable extent, and the supra-spinal muscles act without any antagonizing control; but notwithstanding this, the inconvenience which Larrey apprehends, the permanent extension of the remnant of the bone does not ensue.

The biceps being unattached to the bone, will, when divided, retract cousiderably, the triceps least of all. These points are important, and should be borne in mind. There is no point of the humerus at which amputation may not be performed. The place should be regulated by the extent of the disease, and the rule should be to perform the operation as low as it will allow.

A knife of middling length, bistouri, saw, and a two tailed retractor will be all that is required for the operation.

Circular method.—The patient is placed in a sitting posture, with his arm extended at a right angle from the trunk. The artery being compressed in the same way as in amputation of the fore-arm; the surgeon standing on the outside of the limb, if it be the right arm—on the inside if the left. The first circular incision divides the skin and adipose membrane down to the fascia. (*d, c,* or *f, e,* fig. 21). The assistant makes his retraction, and the skin may be turned inside out, or reflected for some way up the arm. The second incision made on a line with the reflected skin is carried clean through all the muscles to the bone. As the biceps will retract more than the other muscles, it may be divided alone, before the other muscles are cut. A third incision will divide the fibres attached to the bone, and which have retracted least. The radial nerve, lying to the external or posterior side of the bone and close to it, should be clearly divided in this last incision. The retractor is then applied, and the bone is sawed through in the usual way. The last incision of the muscles should, in general, be three inches higher than that which divided the skin. Some surgeons recommend a still further detachment of the muscular fibres, to the extent of an inch up the bone, in order to give additional security against denudation afterwards.

Fig. 25.

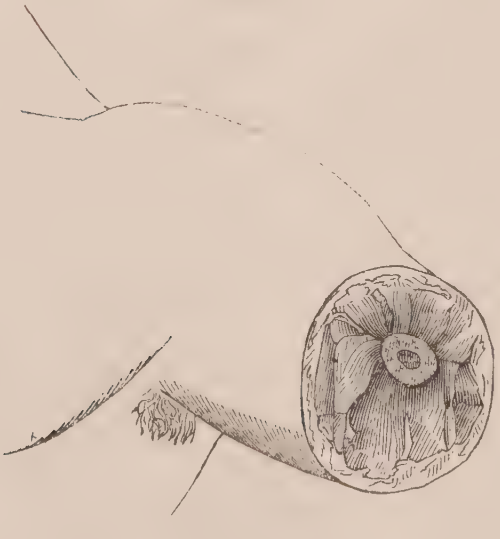

Fig. 25. *Circular amputation of the fore-arm* (*f, e,* no. 1, fig. 20); *the humerus is seen surrounded by the muscles; the arm is extended.*

The brachial artery should be tied; it will be readily found on the inner side of the bone, between the biceps and triceps, together with its two satellite veins, and the median nerve. If any of its branches bleed, they should be also tied or twisted. The cicatrix should form a line from front to back; or it may be oblique, and the lips of the wound brought together accordingly. Some surgeons unite by a transverse cicatrix.

Flap method—with a single flap.—Sabatier recommends the formation of a single flap, when amputation is performed on the humerus, above the insertion of the deltoid, on a level with the axilla. He forms a square flap out of the deltoid, by incisions, two longitudinal and one transverse. This flap being reflected back upon the joint, a semicircular incision divides the skin and muscles on the inside of the limb down to the bone, and the bone is sawed across. In this amputation, as there is no room for commanding the artery, either by manual compression against the humerus or by the tourniquet, compression should be made on the artery above the clavicle, against the second rib.

With two flaps.—(*f, e, d,* no. 2, fig. 20). This is a favourite method in Germany, having been put in vogue by Langenbeck and Græfe, the heads of that sect of surgeons not improperly named *Rapidists,* who place all the glory of an operation in the rapidity of the performance, and estimate its perfection in the inverse ratio of its duration.

The assistant, drawing the skin tightly up, the flaps are formed in the usual way, and may be either lateral, or anterior and posterior. They are cut to the length of three or four inches.

Fig. 26.

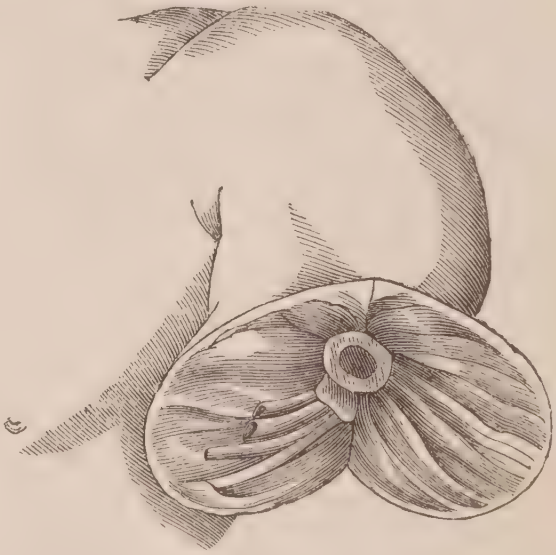

Fig. 26. *Double flap amputation of the arm just below the insertion of the deltoid: the large vessels and nerves are exposed on the surface of the internal flap; the sawed extremity of the bone is seen in the midst of the soft parts on the line of union of the two flaps.*

The oval method has been resorted to by Mr. Guthrie, in amputating the humerus as high up as the axilla. The mode of making his incisions is the same as that employed by him in his amputation at the shoulder-joint, except that the angle of the V does not ascend to the acromion.

The circular method for amputating the arm is preferable to any of the other modes, more especially when a sufficient quantity of integument can be preserved. In particular cases, however, as, for instance, when the skin has been extensively destroyed, the advantage may be turned in favour of the other methods.

SHOULDER-JOINT.

Fig. 27.

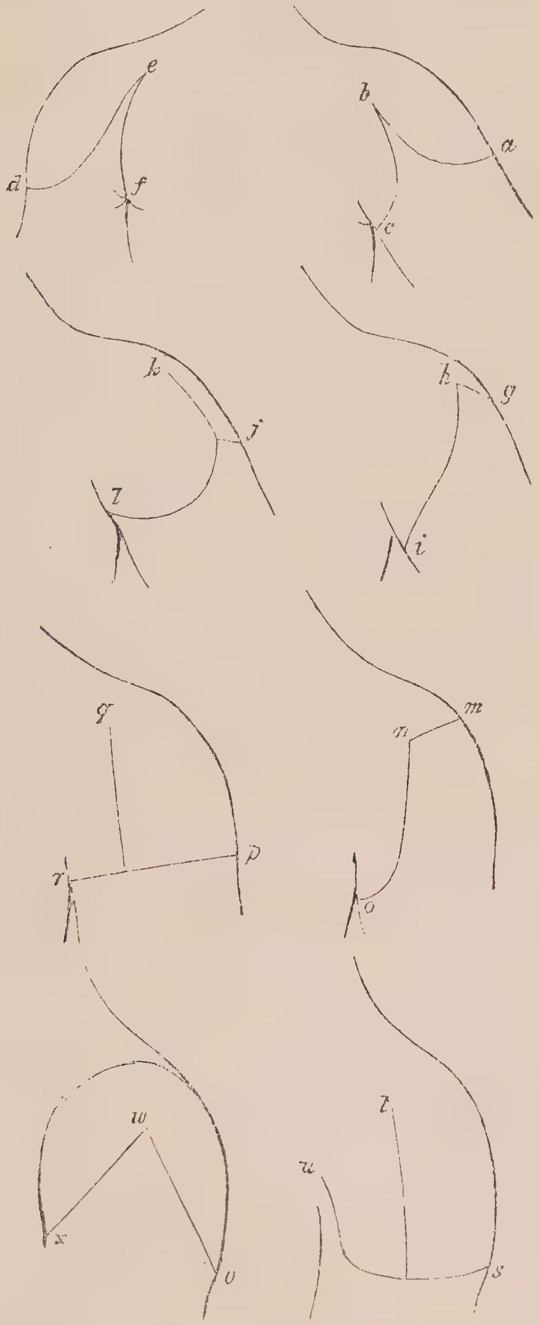

Fig. 27 *shows the lines of incision forming the flaps in amputation at the shoulder-joint, as performed by several eminent surgeons: a, b, c, double flap (Dupuytren); d, e, f, double flap (Lisfranc); g, h, i, double flap (Guthrie); i, k, l, double flap (Dupuytren); m, n, o, single internal flap (Ledran); p, q, r, circular and perpendicular incision (B. Bell); s, t, u, triple flap (Bromfield); v, w, x, the oval method (Scoutetten and Cornuau).*

This articulation differs considerably as to form and composition from any other in the body. The head of the humerus presents the form of a hemisphere, which is rather applied against, than fitted to the glenoid cavity of the scapula, not more than one third of it being received into that articular depression. A loose capsular ligament, attached to the circumferences of each of the articular surfaces, completes the articulation. Large muscles from the front and back of the trunk give strength and support to the joint, while two bony projections, the coracoid and acromion processes, united by a strong horizontal ligament, afford protection above. The half arch thus formed projects more than an inch beyond the glenoid cavity, and may serve as a guide to the articulation. These two processes often remain for a long time unossified; a circumstance to be borne in mind, on account of the facility it will afford the surgeon for disarticulating the head of the humerus in young subjects.

It will be gathered from this brief description, that the projection of the acromion and coracoid processes is at once a guide, and an obstacle to the operator; and that as they over-shoot the joint so much, it will be necessary to preserve a large portion of soft parts to cover them.

Amputation at the shoulder-joint.—The peculiarity in the form of the shoulder-joint, and the abundance of soft parts that surround it, have given rise to great variety in the modes proposed for the performance of amputation at this point. The circular, flap, and oval methods distinctively, or steps combined from all three have been employed, according to the fancy of the operators. Indeed, it may be said, for this amputation, that each surgeon has a method of his own. We shall only notice those most commonly practised.

With a double flap.—The flaps are formed variously, according to the modification of the flap method that may be adopted. All the modifications, however, may be reduced to two classes, according as the wound has a transverse or a vertical direction. Lafaye's plan, which was an improvement upon that of Ledran and Garengeot, is practised in the following manner:—The patient is seated on a chair, and the arm is held extended in the horizontal position. The surgeon makes a transverse incision on a line corresponding with the insertion of the deltoid. Two other incisions, one internal, from the tip of the coracoid process, the other external, from just behind the acromion, are carried down to the extremities of the first incision. A square flap is thus formed, which, being dissected up the articulation, is laid open. The capsular ligament is cut under the head of the humerus, which, on the arm being raised, is at once luxated. The operator thus obtains room to tie the axillary artery high up; which done, he detaches the arm from the trunk. Surgeons, at the present day, do not tie the artery before terminating the operation; they prefer stopping the circulation by causing the lower flap to be compressed by the hands of an assistant. The loss of blood is thus prevented fully as well, while the dismemberment is more prompt.

Dupuytren's plan differs from that of Lafaye in the manner of forming the deltoid flap.

The whole bulk of this muscle is grasped, and lifted from the side of the humerus; a double edged catling is then passed immediately below the acromion under the muscle, which it detaches, at a single incision, from the bone to the required extent (*b*, *a*, fig. 27). The arm is then quickly brought from the horizontal into parallelism with the trunk. By successive rotatory movements of the head, the tendons of the muscles round the joint are made tense and divided, beginning by those on the back of the joint. The head of the bone is luxated, the assistant pinches up the lower flap, and the limb is detached, as in Lafaye's method, by cutting the attachments of the pectoralis major, and latissimus dorsi, (*b*, *c*, fig. 27). This plan is more simple and expeditious than that of Lafaye, while its result is the same.

Fig. 28.

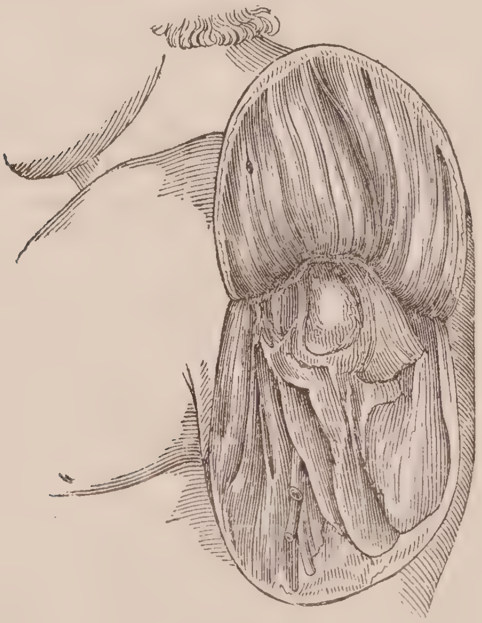

Fig. 28. *Double flap, a superior and inferior one, for amputating the arm at the shoulder-joint: the large vessels and nerves are exposed on the surface of the inferior flap; the glenoid cavity of the scapula is seen in the midst of the soft parts, a little below the line of junction of the flaps.*

The method of forming the deltoid flap may also be reversed. Mr. Cline used to cut the deltoid from its attachment up to the articulation, through which he passed the knife with amazing rapidity, and finished the incision by forming the under flap. In his operation, the whole seemed to be effected in one stroke. He made compression of the artery on the first rib. To do it well requires great habit; but it will be found more expeditious even than Dupuytren's.

Lisfranc's plan.—The patient is seated on a chair; one assistant stands behind him ready to compress the artery in the inferior flap, another at his side to reflect the deltoid flap. The limb is drawn slightly towards the trunk, or allowed to hang down. The surgeon, standing in front or at the side, passes the point of his narrow double-edged knife into the triangular space existing between the coracoid process and the anterior and outer edge of the clavicle, in a direction somewhat oblique from above downwards, passing under the acromion; before it reaches the axilla, the handle is raised as much as possible, so as to make the point come out very low down, and within the posterior border of the axilla. He then lays firm hold of the arm and draws it downwards, in order to separate the articular surfaces; the edge of the knife near the handle is next disengaged from the point of the acromion process by depressing it, cutting towards the coracoid process, and then directing the edge of the knife downwards on the outside of the arm, he forms a flap about three or four inches long (*e*, *d*, fig. 27), which is immediately reflected back by the assistant. In this first incision the articulation has been laid open; the head of the humerus is now raised, and the knife is passed through the joint to the inner side; the other assistant seizes the lower flap above the edge of the knife, makes a sign to the surgeon that he commands the artery, who then cuts on the inside of the humerus to form the lower flap (*e*, *f*, fig. 27).

This plan belongs exclusively to Lisfranc. It has also been reversed both by Champesme and Lisfranc himself. When the operation is performed according to this plan, the point of the knife is made to enter within the border of the axilla, the blade ascending obliquely, so as to form an angle of from 30° to 35° with the axis of the shoulder, the edge turned a little in front, and coming out in the coraco-clavicular space, in front of the acromion. The arm is then pulled downwards, and the point of the knife is pressed towards the coracoid process, so as to free it from the anterior point of the acromion; the flap is then formed as before.

The first mode will be most easily followed in amputating the right arm; the second may be employed for the amputation of the left. This operation is performed with great rapidity, and the disarticulation is easily effected, owing to the division, by the first incision of the tendons that cover the back of the joint.

With three flaps.—Larrey has performed amputation frequently in the shoulder-joint by the following method:—The arm being carried a little away from the trunk, the surgeon commences a longitudinal incision at the point of the acromion, prolonging it downwards in the middle of the deltoid, for three or four inches, and dividing this muscle into two equal parts, (*a*, *b*, fig. 27); the arm is then put in the horizontal position; and the knife is passed from the first incision, first behind the humerus, (*a*, *c*), then, in front (*a*, *d*), till the point, in both instances, shows itself within the corresponding border of the axilla; and two small flaps are thus cut, which the assistants immediately raise and reflect. The articulation thus laid bare above is opened, and the knife carried on the axillary side of the humerus; time being given for the assistant to command the artery, the inferior flap is formed in the usual way.

In forming the first two flaps, the circumflex artery may be divided; in that case, the assistant, who has charge of the flap, must stop the hæmorrhage by compressing it with his fingers, so that the surgeon shall not be diverted from pursuing the remaining steps of the operation.

Fig. 29.

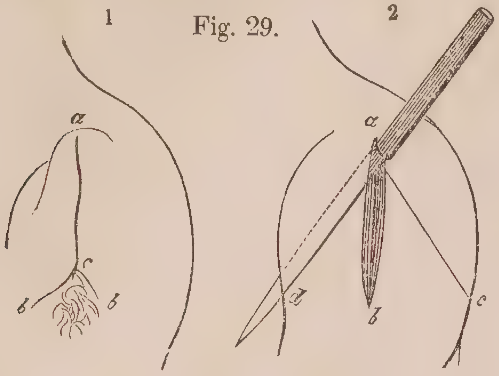

Fig. 29. *Larrey's triple flap for amputation at the shoulder-joint. No. 2 shows the lines of the incisions; No. 1, a, b, c, b, the wounds cicatrized.*

Oval method.—Mr. Guthrie has recommended this method of operating at the shoulder-joint. The operation is performed in the following manner:—As the two incisions (*i, h, y*, fig. 27) to form the V unite at the acromion, they are both begun from this point. The surgeon, placing himself outside the patient, carries the arm a little away from the trunk. He makes the first incision, at the back of the joint, directing the knife obliquely from the acromion, and carrying out the point within the corresponding border of the axilla, at its lower part. He then makes another from the anterior border of the axilla, to the point of the acromion. These flaps are both turned and held back, and the articular capsule is exposed at its upper and back part. It is then laid open and the head of the bone luxated. The knife is carried to its axillary side, and the assistant holding the artery compressed in his fingers, the separation of the limb is completed by cutting downwards; the basis of the V being thus the last part on which the knife is made to act.

Fig. 30

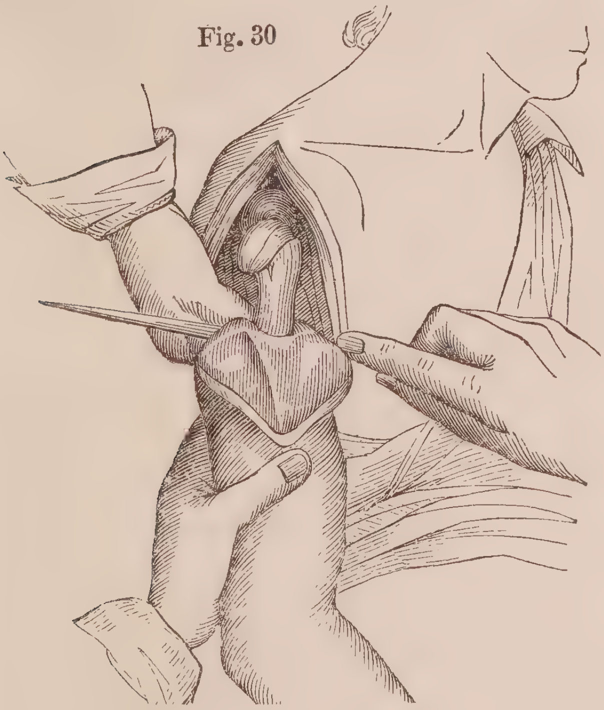

Fig. 30, *Mr. Guthrie's method of amputating at the shoulder-joint, modified by Velpeau. The head of the humerus is seen disarticulated, and the knife, carried to the inside, is ready to separate the limb from the trunk. The assistant's thumb, inserted deep into the wound, is compressing the artery, by grasping the flap between his thumb and fingers.*

Mr. Guthrie's method is also practised by making the incisions from the surface to the articulation; first, dividing the integument only, retracting it, and then cutting the muscles. When the shoulder is very full, this plan will afford additional facility. Velpeau alludes to a difficulty which is encountered in opening the capsular ligament, which, unless thrown on the stretch, yields before the edge of the knife, and remains undivided. It will be obviated in the manner already described, either by pulling the arm downwards, or by rotating the head of the bone, and tightening the capsule and tendons upon it. The oval method differs but little from the triple flap method of Larrey. If the circumflex artery is opened in the first incision, the assistant, in holding back the flap, must command it, as in Larrey's plan.

Circular method.—Alanson's plan for performing this operation is, an incision, which divides the integuments only, encircling the arm, between three and four inches below the acromion. An assistant retracts the skin; the deltoid is then cut obliquely from below upwards, until the articulation is reached; another incision opens the capsule, and cuts the tendon of the biceps. Arrived at this stage of the operation, modern surgeons cause the artery to be compressed before the soft parts in which it lies imbedded are cut. The capital fault of the circular method, as practised by Alanson and Garengeot, was that they previously resorted to the ligature *en masse.* This operation by circular incision is difficult; but the result, as regards a good stump, is perhaps the best that can be obtained.

The amputation at the shoulder-joint is not an operation of so modern a date as has been supposed. Laroque relates a case in which it was performed, in 1686, for gangrene of the limb:—"The surgeon had taken a small saw to amputate the humerus, but perceiving that it was loose in its articulation with the shoulder, he drew on it with some force, and the bone came out of its socket; after which, the boy recovered quickly." But though the idea of it might have frequently occurred, it was not put in execution till the time of Ledran. The simple method of commanding the axillary artery, by compressing it in the flap, has, doubtless, had a share in obtaining for it much of the favour which it enjoys at the present day. It cannot now be ascertained to whom we are indebted for this improvement; but it is mentioned by Pojet in 1759, and by Bertrandi in 1763.

From the great number of modifications of the different methods applicable to this amputation, it may be inferred, that although there is none which deserves an exclusive preference, yet, that each may possess advantages according to the nature of the case, which will render it more eligible than any other. With the general descriptions given above, the selection of the method, or the combination of different modifications best suited to the particular case, may be safely entrusted to the practitioner's own judgment.

For the prevention of hæmorrhage, the preliminary ligature *en masse*, as practised by Ledran and Garengeot, is now totally laid aside. The axillary artery is first secured, next the circumflex, and then any smaller vessels that are found to give blood. The dressing is performed in the usual way by the confrontation of the flaps, or lips of the wound. It should be rendered compressive from the trunk towards the stump, with a view to prevent pus from fusing in that direction.

SHOULDER.

Although the proposal to remove parts of the scapula or clavicle, when diseased, may seem a bold one, it has been effected, both by accident and by operation, without destroying life. Larrey has, in several instances, removed with complete success a large portion both of the scapula and clavicle. Mr. Cumming performed the entire ablation of the shoulder, in the Antigua Hospital in 1808, and the patient recovered perfectly. Many cases are also recorded, in which the shoulder was torn from the body by machinery, and the patients nevertheless recovered.

Whenever a portion of these bones is to be removed by the surgeon, he must trust to his experience and anatomical knowledge: to those resources, in a word, which qualify him for undertaking and carrying through a surgical proceeding for which no precise rule can be laid down, every step of which, from beginning to end, being dependent on the nature of the case. The preservation of sufficient soft parts to cover the stump well is an important point, and wherever it can be effected, by adhering to ordinary rules, the surgeon should be guided by them.

INFERIOR EXTREMITY.

Amputations are performed on the abdominal limb, either in the continuity or in the contiguity. The object, however, which recommends amputations in the contiguity so extensively in the thoracic limb, namely, the preservation of as much as possible, is by no means so imperative in the case of the lower limb.

Fig. 31.

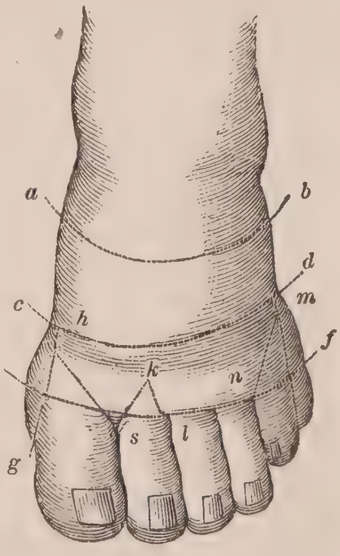

Fig. 31 *represents the lines of incision made in amputations of various portions of the foot: a, b, the dorsal incision for Chopart's amputation; c, d, the dorsal incision, for amputation of the metatarsal bones, from their articulations with those of the carpus; e, f, the dorsal incision for the amputation of all the phalanges; g, h, s, two oblique incisions for removing the great toe by the oval method; s, k, l, two similar incisions for the removal of the next toe; n, m, f, two oblique incisions for the amputation of the little toe; the prolongation of the line, m, f, shows the manner in which the flesh of the sole of the foot spreads beyond and under the toes. All these transverse lines appear nearer to each other, on account of the foot being foreshortened.*

Amputation of the first phalanx of the great toe.—When the disease affecting the ungual phalanx of the great toe has spared the soft parts on the plantar surface, and a sufficient flap can be formed, it will be proper to remove the phalanx only. The same rule applies as in the amputation of the first phalanx of the thumb, allowing merely for the larger size of the articular surfaces of the toe: to describe the mode of proceeding would therefore be a repetition.

Amputation of the toes in the articulations of the phalanges with the metatarsal bones.—The phalanges of the toes are so short, and their removal impedes so little the functions of the foot, that, with the exception of the great toe, the surgeon has no object in saving the first phalanx, even when the disease or injury is limited to the second, and he therefore performs the amputation at their articulations with the bones of the foot.

The junction of the toes with the metatarsal bones is marked on the dorsal surface of the foot by a depression. The transverse line on the plantar surface is also much deeper than in the hand, owing to the prominence or fulness of the sole of the foot, which advances here, as it were, under the toes. The same methods of effecting disarticulation are practicable, as in the case of the fingers; but their execution is not quite so easy. The oblique method is perhaps the best.

Fig. 32.

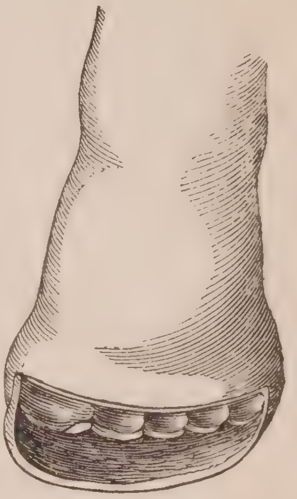

Fig. 32. *Lisfranc's plan for removing all the toes together; the ends of the metacarpal bones are seen in the wound; the flap is formed from the soft parts in the sole of the foot.*

Lisfranc's plan of removing the fingers by the flap method is applicable also to the toes, either singly or together.

Amputation of the great toe in its articulation with the metatarsal bone.—The propriety of performing this operation has been a subject of discussion. It has been urged on the one hand, that when the great toe is removed, it is difficult to obtain a sufficient covering for the head of the metatarsal bone, on account of its great size, and that the cicatrix is exposed to painful friction; and for these reasons, that an operation in the continuity of the metatarsal bone is much to be preferred. On the other, it is maintained that the head of the bone ought to be preserved on account of its importance to the due performance of the functions of the foot, and that its removal will cause the foot to turn in. With due care, however, in performing the operation, a sufficient covering can almost always be procured. If the disease did not extend as high up as the articulation, the surgeon might easily avoid the difficulty of procuring a sufficient covering for the articular head of the metatarsal bone, by amputating in the continuity of the first phalanx in the same way, as if he was operating on the thumb. The small sesamoids may be left in the flap.

Fig. 33.

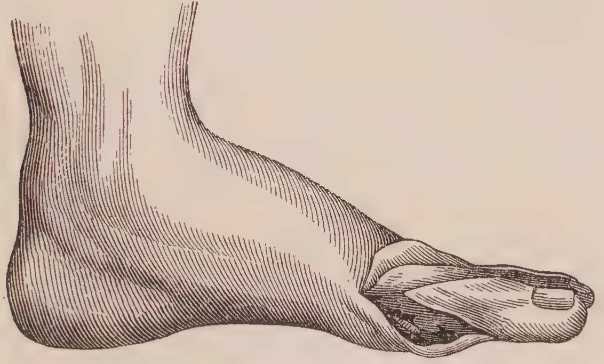

Fig. 33. *Amputation of the great toe in its articulation with the first metatarsal; a great part of the flap has been taken from the skin and soft parts on both sides of the toe.*

Amputation of the little toe in its articulation with the metatarsal bone.—Should the oval method be inapplicable the flap may be formed from the side of the toe, as in the accompanying figure.

Fig. 34.

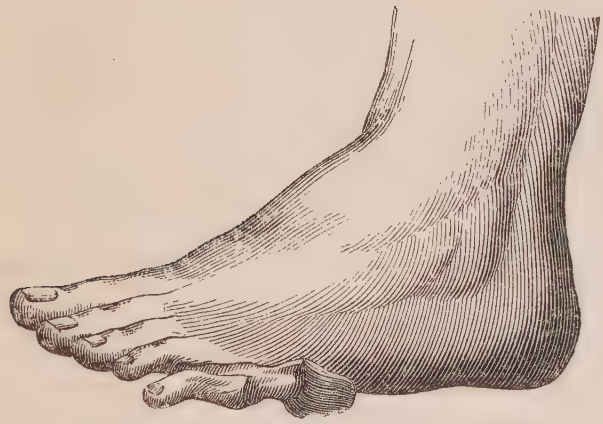

Fig. 34. *Amputation of the little toe in its articulation with the fifth metatarsal; the flaps taken from the skin and soft parts on both sides of the toe.*

Amputation of the metatarsal bones in the continuity.—These bones are more closely set together than their analogues in the hand, and hence a greater difficulty in using the saw, more especially on the three central ones.

Metatarsal bone of the great toe.—At the present day no surgeon thinks of attacking this bone in its tarsal articulation, for a disease which can be removed by sawing the bone in its continuity, particularly since Richerand's method of sawing it obliquely has put an end to the inconveniences which used to arise from its transverse section. Nor, on the other hand, does any one now maintain, that the metatarsal bones should be attacked in their continuity for a disease, which is removable by amputating at their articulations with the toes.

As was stated of the metacarpal bones, the metatarsal bone, supporting the great toe, has been removed, without extirpating the toe itself. But this class of operations belongs to the article Resection, to which the reader is referred.

The flesh is so unyielding under this bone, that it cannot well be pinched out into a bulky flap, allowing the knife to run down the side of the bone, as when we amputate the corresponding bone of the thumb; it will, therefore, be better to make an incision along the side of the bone, and penetrating to it throughout its entire length, until it reaches the phalanx; the soft parts are then detached from the dorsal and plantar surfaces of the bone. These flaps are then held back towards the fibular side of the foot, so as to allow the knife to pass, at the upper part of the wound, into the interosseous space without wounding the edges, either above or below the foot; the knife is then carried rapidly along the inside of the metatarsal bone, until it comes clear out at the interdigital commissure. The bone is next cleared of the soft parts still adhering to it, and a peace of wood, pasteboard, or a linen compress in several folds, being placed in the angle at the upper part to protect the foot, the saw is carried through the bone, in an oblique direction from within outwards and forwards. The arteries are tied, the flaps brought together, and a compressive dressing applied.

Fig. 35.

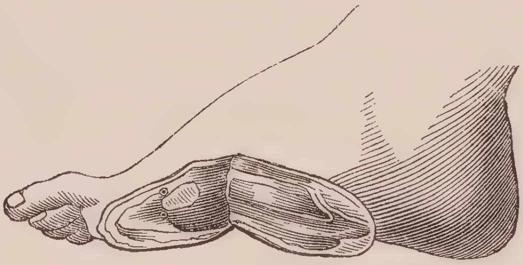

Fig. 35. *Amputation of the metatarsal bone of the great toe in the continuity; the flap is thrown back towards the heel, and the bone is seen sawed in splice.*

Oval method.—When this method is resorted to, as it almost always is, a dorsal incision, beginning at the upper part of the bone, is carried down to the digito-plantar line that marks on the plantar surface the junction of the toe and sole of the foot; the incision continues in this line, till it reaches the commissure, which it divides, and ascending on the inside of the bone, joins the first incision obliquely, a little below the point where it commenced (*g, h, s,*—*s, k, l,*—*n, m, f,* fig. 31). The soft parts are then detached from the bone above, and it is sawed obliquely through, as before.

Amputation of the fifth metatarsal bone in its continuity.—The reasons that bind the surgeon to operate in the continuity of the first metatarsal bone no longer have the same cogency in the case of the fifth. Its removal at the articulation leaves but little or no deformity, the disarticulation is easily effected, and the portion of bone that would be preserved by operating in the continuity can be but of little use. If, however, the surgeon should prefer it, the bone should be sawed in splice, in the same manner as recommended for the first metatarsal (fig. 35).

Fig. 36.

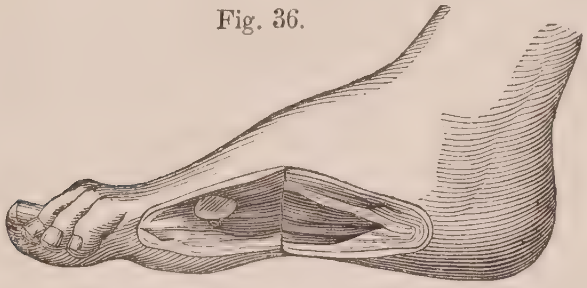

Fig. 36. *Amputation of the metatarsal bone of the little toe in the continuity; the flap is thrown back towards the heel, and the bone is seen sawed in splice.*

The oval method, performed as already described for the little finger, will be the most suitable.

Amputation of the middle metatarsal bones in the continuity.—The rules laid down for the removal of the metacarpal bones to which the reader is referred, are again strictly applicable to the metatarsals. The bones are to be sawed off, one after the other, and the same precautions should be taken to prevent the fusing of pus along the tendinous sheaths.

Fig. 37.

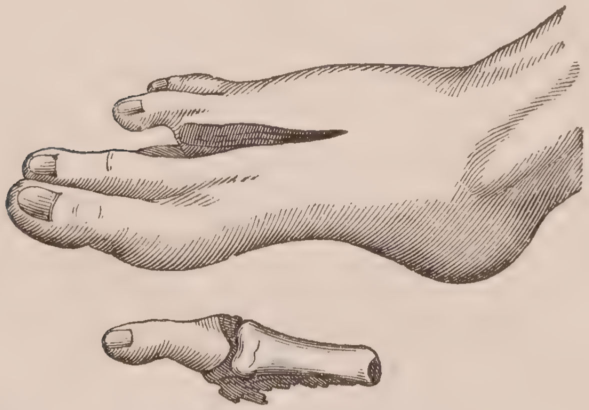

Fig. 37. *Amputation of the middle metatarsal bone in the continuity. The small fig. shows the bone and toe that have been removed; the bone has been sawed transversely, which is not so advantageous as the splice section.*

PARTIAL AMPUTATIONS OF THE FOOT.

Prior to the establishment of partial amputations of the foot as a rational surgical proceeding, the only resource for the lesions, which are now treated by this form of operation was the amputation of the leg itself; a resource involving the loss of all the sound parts between the place to which the disease was limited and the leg. The successful results of attempts to save the wrist, by partial amputations of the hand, at length opened the eyes of surgeons to the possibility of avoiding the unnecessary sacrifice of the ankle and heel. It was not, however, till the time of Chopart that the process began to obtain confidence.

Partial amputations of the foot are mentioned by Garengeot as performances of great difficulty, from the number and irregularity of the joints and ligaments.

These amputations are performed at two particular points: in the articulation of the astragalus and os calcis, with the scaphoid and cuboid; and at the junction of the metatarsal with the tarsal bones. Sharp and Hey were among the early advocates of these disarticulations; but, although they may have been executed by others prior to that period, the operation is first mentioned as having been successfully performed in this country by Mr. Turner of North Yarmouth, in 1787[1]. It was also performed in 1789 by Baron Percy, and in 1793 by Larrey.

Those, however, who had performed it successfully, described it vaguely, and almost in terms of discouragement to those who might be disposed to imitate them. In consequence of which, the partial amputation of the foot did not receive all the attention it deserved until the year 1815, when the presentation of an able memoir by Lisfranc to the Institute of France, made it a subject of discussion.

Fig. 38.

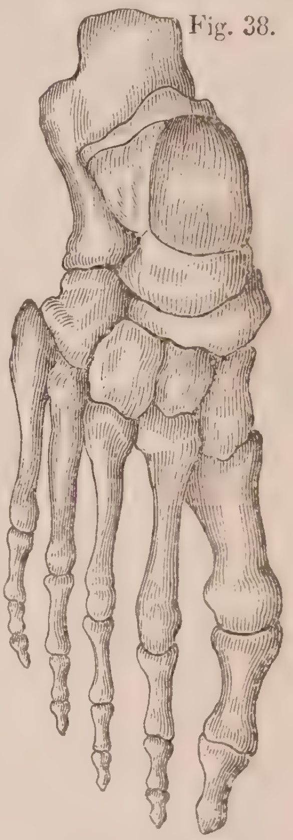

Fig. 38. *Skeleton of the foot. The articular interlines are shown very distinctly, and will serve as useful guides in studying the partial amputations of the foot.*

Amputation of the metatarsal bones in their articulations with the bones of the tarsus.—These articulations range the foot transversely, but in a line extremely irregular and intricate. The bones composing this line of junction are the three cuneiforms, and the cuboid on the one hand, with the five metatarsals on the other. The obliquity of the line is so great, that its commencement at the inside of the foot is nearly an inch farther forward than its termination on the side of the little toe. The prominence of the tarsal end of the metatarsal bone of this toe will serve as a guide to the interline that separates this bone from the cuboid. If a line be drawn from this point straight across to the inside of the foot, the interline separating the metatarsal of the great toe, and the cuneiform will be three-fourths of an inch further forward towards the toe. This interline will also be easily discovered under the skin, by feeling towards the sole of the foot for the two prominences formed, just at their junction, by the cuneiform and the metatarsal bones; the line between them is that of their articulation. From this point, if we trace the articular interline, on referring to plate (38) we shall see that it runs between these two bones with a double obliquity, first downwards and outwards, then upwards and outwards, and terminating against the side of the head of the second metatarsal, about four lines lower than its junction with the second cuneiform. To this extent it ascends directly backwards, between the side of the first cuneiform, and that of the head of the second metatarsal; it then proceeds transversely between the second cuneiform and second metatarsal, till it meets the third cuneiform, along the side of which, to the extent of two lines or a little better, it runs again directly forwards, with an inclination outwards. This encroachment of the second metatarsal upon the second cuneiform, forming a sort of mortice, is compensated for by a similar encroachment, in an inverse direction, of the third cuneiform upon the third metatarsal. The line then passes from the outside of the head of the second metatarsal, obliquely, between the third cuneiform and third metatarsal, and impinges upon the side of the head of the fourth metatarsal, and runs again directly backwards, between it and the outside of the third cuneiform; from this point it runs between the cuboid and the fourth and fifth metatarsals in a curve outwards, and obliquely backwards, and terminates behind the tubercle of the latter bone.

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[1] Hutchison's Practical Observations, p. 70.

Anomalies are also sometimes observed in the course of the articular interline; the bones may be more deeply morticed into each other, or, on the contrary, the mortices may be so shallow as to render the articular interline nearly straight. In this case there would be a corresponding facility in the operation. The tubercle of the fifth metatarsal has been known to be prolonged so far backwards as to join the side of the os calcis; sometimes the articular surfaces are ankylosed; and it should not be forgotten that the heads of the metatarsal bones, and the tarsal bones are not ossified to such a degree as to render section with a knife impracticable in young subjects up to the thirteenth or fourteenth year. The ligaments on the dorsal surface are short fibrous bands; the plantar ones are much thicker and stronger, and fill up the spaces between the bones; the interosseous are very powerful, and on that account are the most embarrassing to the operator. In order to be prepared for the difficulties of this operation, the surgeon should be ready to use the saw, when the point of his bistouri is insufficient to effect the disarticulation. Hey, in a case in which he operated in 1799, sawed off one-half of the large cuneiform bone; the head of the second metatarsal, if it was too firmly locked between the three cuneiform bones, might be left in the stump, by sawing it across in a line from the articulation of the first to that of the third metatarsal.

Lisfranc's method.—The knife or bistouri should be slender and have a solid back. If the surgeon is ambidextrous he will perform the operation with the right hand on the right foot, and with his left if the disease be of the left foot. If he uses the right only, he commences his incision, on the first or on the fifth metatarsal, according to the foot on which he has to operate. The patient is placed on a table or bed, in a sitting or reclining posture, the leg half-bent, and projecting beyond the edge of the bed. An assistant supports it, and, at the same time, keeps it turned inwards; another compresses the anterior and posterior tibial arteries, the former on the instep, the latter behind the internal malleole, while he also draws back the skin on the back of the foot. The surgeon, guided by the indications already given, ascertains the two terminations, external and internal, of the line of the articulations, and holding the foot in the palm of his hand, the thumb and index finger supporting the fifth metatarsal, if it be the left, the first if it be the right, he makes a semilunar incision, convex towards the toes, extending across the back of the foot, commencing and terminating at the two extremities of the articular interline. At this stroke, the integuments and cellular tissue alone are divided; these being retracted, the extensor tendons and other soft parts are divided by a second transverse incision, corresponding to the line of the articulations. The point of the knife is now employed in opening the joints, beginning behind the tubercle of the fifth metatarsal; after separating the fourth and fifth from the cuboid, the knife is stopped by the side of the third cuneiform; carrying the point a little forwards, it passes between the cuneiform and third metatarsal, and is again stopped by the side of the head of the second metatarsal. He then turns to the inside of the foot, and still using the point only, he separates the large cuneiform from the first metatarsal, until stopped by the head of the second metatarsal. The head of this bone, locked in between the three cuneiforms by strong ligaments, will hold firm until these are divided. The back of the knife is then inclined towards the toes, the edge towards the leg, and the point is passed between the first cuneiform and second metatarsal, until it reaches the depth of the articulation; the handle is then raised to the perpendicular, and the internal interosseous ligament is divided.

Fig. 39.

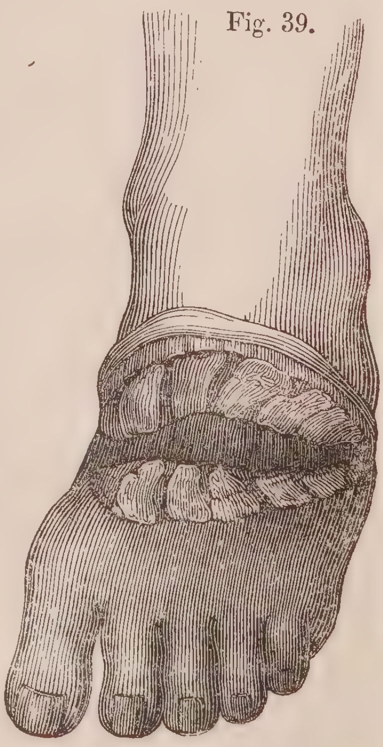


Fig. 39. *Lisfranc's partial amputation of the foot, in the articulations of the heads of the metatarsals*

with the tarsal bones. The metatarsals are luxated; and the anterior part of the foot is hanging by the soft parts of the sole, from which the flap is about to be formed.

By repeating the manœuvre at the top of the head, and at the other side, the strong ligaments are all divided, and this *key-stone* of the articular arch being freed, a slight pressure will throw downwards the anterior portion of the foot, and open wide the whole line of the articulations; the remaining ligaments are divided, and the knife is brought on the flat, between the under surfaces of the bones, and the sole of the foot. The point of the knife ought to be used for detaching freely the plantar ligament from the upper ends of the metatarsals, in order that the knife may lie well on the flat before the flap is cut. The inside of the flap should be two inches long—the outer, little more than one; its form must be slightly rounded to correspond with the semicircular curve of the upper part of the stump, and it should be cut out bevelled to the skin. If any tendons hang upon its surface, they must be cut clean off with a pair of strong scissors.

Fig. 40.

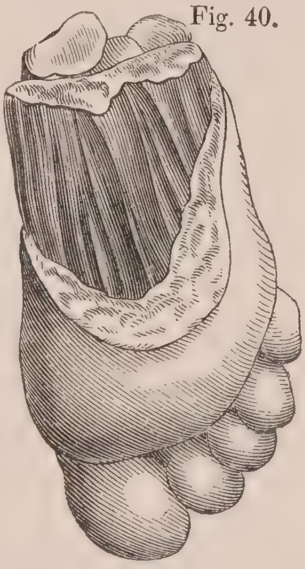


Fig. 40. *The foot removed shows the section of the soft parts of the sole to form the flap.*

The bleeding vessels are tied or twisted, the flaps brought together by adhesive straps, and the patient is placed in bed, the leg half bent, and resting on its outside, so as to favour the exit of any matter that may form in the wound. The same precautions to prevent the pus from fusing along the tendinous sheaths will be necessary as in amputation of the carpus. The bandages must be in a proper degree compressive from above downwards.

In casting an eye over the structure of tarso-metatarsal articulations, it will be perceived, that if only one or two bones are diseased, the ablation of the sound ones would be unnecessary. In a case, in which the cuboid bone was diseased, Hey disarticulated it from the os calcis, removing it together with the two outer metatarsals.

Partial amputations of the foot in the articulation of the astragalus with the scaphoid, and of the os calcis with the cuboid.—This operation is known by the name of Chopart's Amputation, and may be performed with much greater facility than the disarticulation we have been just describing. The joints here are much more loose and regular; the whole articular line is composed of portions, both tolerably regular, and easily recognised, on account of the degree of motion which the joint allows. The internal tuberosity of the scaphoid will serve as a guide to the articulation, which, on the inside of the foot, commences immediately behind this prominence. If a line be drawn from this point straight across the foot, it will fall on the articular interline also, just in front of another tuberosity, which can be felt on the outside and anterior point of the os calcis. The ligaments are loose and easily divided; the os calcis and the outer part of the scaphoid, are, however, held together by a very strong ligament, which forms what the French surgeons term the *key* of the joint. The direction of the scaphoid portion of the articular line represents a half-moon with an anterior convexity; that of the outer portion, an oblique plane from within outwards and a little forwards.

The foot is placed in the same position as for the preceding amputation, and the arteries are compressed as before. The surgeon, after having ascertained the position of the two guides to the articulation, takes the foot in his hand, so that the thumb and index-finger shall mark these points respectively, and makes a semilunar incision across the back of the foot from the one to the other (*a*, *b*, fig. 31).

Some surgeons recommend the incision to be made in the line of the articulation itself; but it is better to carry its convexity at least half an inch further forward. The assistant retracts, and the tendons are cut along the line of the articulation. If operating on the left foot, the point of the knife is at once made to penetrate the joint immediately behind the tubercle of the scaphoid, and following the articular line across the foot, completes the division of the dorsal ligaments. By pressing the anterior portion of the foot downwards, the joint is made to gape, and the division of the interosseous ligament is effected with the point of the knife. The bones are luxated, the inferior ligaments are cut, and the knife is turned on the flat in the soft parts of the sole of the foot, which is held in a horizontal position while the flap is cut from the inferior surfaces of the tarsal and metatarsal bones. The bony surfaces to be covered are considerable, and the flap should be in proportion. In general, three or four inches will not be too much. The flap should be somewhat longer for the inside, on account of the greater height of bone. In forming the flap, the protuberances on the plantar surfaces of the scaphoid and cuboid should be avoided, as well as those of the first and fifth metatarsal farther forward.

In persons of advanced years, the interosseous ligament is sometimes converted into bone, and a portion of the articular surfaces may be ankylosed; in this case, the small saw should be at hand to terminate the operation. Before puberty, on the other hand, the bones will be often found in the state of cartilage, or soft epiphysis, in which case the amputation might be performed without following the line of the joints, which might be left as far behind the section as the sound state of the soft parts would permit.

The arteries are tied, and the stump dressed, as in the preceding case.

Those who would execute properly both these amputations, especially the former, must possess exact anatomical knowledge, and that facility which is acquired by amputating frequently on the dead subject. Chopart's operation is much more easily performed; but the disarticulation of the metatarsals gives a more serviceable stump, and spares the tendinous attachments of several important muscles; and this is by no means an inconsiderable compensation for the greater difficulty of the operation. Whenever the disarticulation of the metatarsal bones will meet the necessity of the case it should be preferred. The same observation will hold good as regards Chopart's operation, which ought to be preferred to an amputation of the leg, when the disease has spared sufficient soft parts to form a good covering. It is, however, perfectly true, that in both, the tendons reunite with the stump, and re-establish the power of the muscles over its motions. Some cases have occurred after Chopart's operation, in which the heel has been so much thrown back, as to render the division of the tendo Achillis indispensable.

Fig. 41.

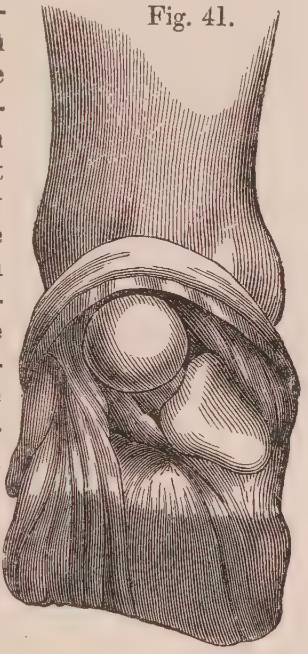


Fig. 41. *Chopart's amputation; the astragalus and os calcis are seen in the wound; the flap that has been cut from the sole of the foot is hanging down.*

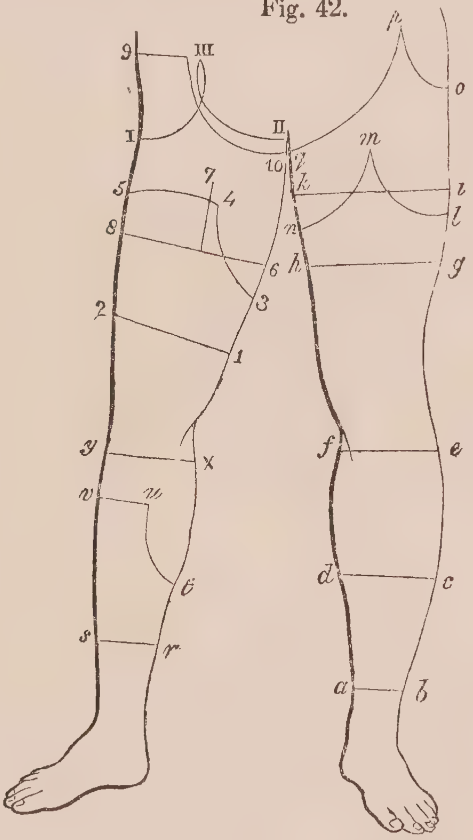
One or more of the tarsal bones have been extracted, and in some instances without impairing, to any great extent, the usefulness of the foot. The astragalus has been thus removed after violent luxation. But the mode of performing these operations cannot be reduced to any fixed rules, and must be left to the judgment of the surgeon.

ANKLE JOINT.

Mention has been made of amputation in the ankle joint at a very remote period. It is, however, seldom practised at the present day, amputation of the leg being generally preferred. Some eminent surgeons have expressed a regret that it should have fallen into such universal disuse. The objections made to it are the extent of the joint itself, and the scantiness of covering. Both these objections are, however, susceptible of mitigation: the extent of the articular surface may be diminished by removing both the malleoles with the saw, a step which will augment proportionately the capability of the soft parts to form a good covering for the stump.

The operation might be performed by making a short flap in front, by a semicircular incision extending from one malleole to the other. As the internal malleole descends less than the outer one, the joint should be opened on that side; the astragalus being luxated, the covering flap should be carved out of the soft parts of the heel. The removal of the malleoles would allow an ample covering for the stump. Lisfranc, in his lectures, mentions a man on whom this amputation had been performed who could walk ten or twelve miles a day with great ease.

Fig. 42.



Figs. 42,43 *represent the lines of incision in amputations performed by the circular, flap, and oval methods on the inferior extremity.* Fig. 42, *Front view: a, b, circular amputation above the ankle; s, r, the same; d, c, at the place of election; v, u, t, single flap at the place of election; y, x, amputation of the tibia in its largest portion, near the articulation, with disarticulation of the fibula; f, e, circular at the knee-joint;* 1, 2, *and g, h, circular at the lower third and middle of the thigh; l, m, n, double flap (Guthrie), upper part of the thigh; i, k, circular, upper part of the thigh; o, p, q, double flap, anterior and posterior (Guthrie, Lisfranc);* 6, 7, 8, *circular incision with double flap (Ravaton) at the upper part of the thigh;* 3, 4, 5, *single internal flap at the upper part of the thigh;* 9, 10, *single flap for amputation of the hip-joint;* I. II. III. *double-flap, internal and external (Larrey), for amputation of the hip-joint; the little elliptical space under* III. *indicates the line of incision first made, to secure the femoral artery.*

THE LEG.

In the leg there are two bones of unequal size, placed nearly in the same line; the larger, the tibia, being on the inside; the smaller, the fibula, on the outside, and somewhat backwards. Behind, the backs of both are covered with strong muscles; in front, the space between them is also filled with muscles. The inner surface of the tibia is covered only by the skin. The fibula also at its inferior part becomes subcutaneous. The soft parts diminish in bulk from above downwards, so that the limb tapers, both bones becoming comparatively divested of muscles, in approaching the ankle.

Fig. 43.

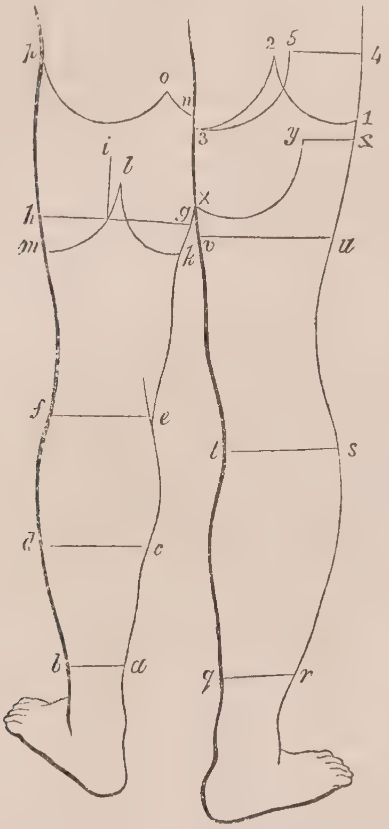


Fig. 43. *Back view: a, b, and q, r, circulars, above the ankle; d, c, circular at the place of election; t, s, circular amputation, in the broad upper part of the tibia near the articulation, with disarticulation of the head of the fibula; e, f, circular at the knee-joint; k, l, m, double flap at the middle of the thigh; u, v, circular, at the same point; h, i, g, circular incision with the subsequent formation of two flaps (Ravaton) at the upper part of the thigh; x, y, z, single internal flap at the upper part of the thigh;* 1, 2, 3, *double flap, internal and external (Larrey) for amputation at the hip-joint;* 3, 5, 4, *single internal flap for the same; h, o, n, double flap, anterior and posterior (Guthrie), for the same.*

Several circumstances concur to fix a place of election for amputating the leg. The preservation of the tendons of the flexors that bend the leg upon the thigh forbids cutting as high up as the tubercle of the tibia. The inconvenience of a too long stump, bent backwards from the knee-joint, to which in these cases, the artificial leg is adapted, forbids the section at the lower part of the limb. The place of election for amputating the leg is therefore fixed at four fingers' breadth, below the tubercle of the tibia, for an adult. But when the injury involves the place of election itself, many eminent authorities recommend amputation above this point in preference to an operation either at the knee-joint, or on the thigh. Larrey performed this amputation several times, even above the tuberosity of the tibia, at the same time disarticulating, instead of sawing the head of the fibula.

Mr. Guthrie approves also of this practice, of sawing the tibia in its broad spongy texture, near the articulations. For others, however, the place of election is much lower than we have stated, and even some have contended that the rule of saving as much as possible, is just as applicable in the leg as in the fore-arm. The cicatrix, it is true, is obtained, perhaps with equal facility; but the difference in regard to functions of the fore-arm and leg is altogether in favour of the former, while it is decidedly against the latter. If an artificial hand be adapted to the stump of the fore-arm, the cicatrix is not painfully pressed by it, and it produces no further inconvenience than what might be expected to arise from its weight, while it saves the free use of the elbow-joint; but the cicatrix in the lower part of the leg has to bear the weight of the body between the ends of two bones, and the pad of the artificial leg. The only circumstance necessary for the revival of the practice of amputating in the lower part of the leg is the possibility of securing protection for the cicatrix. The means hitherto employed for the purpose have not been, generally speaking, efficient; and in not a few instances, persons with these stumps have of their own accord solicited the performance of a second amputation higher up, to rid them of the evils they entailed upon them. Very possibly, however, this may be a difficulty which the art is destined to triumph over, by a skilful adaptation of mechanical means.

Amputation of the leg at the place of election.—Whenever there is room to perform it, and we have already stated, that the tibia may be sawed in its spongy head, as high up as the articulation of the fibula, this amputation is in all cases preferable to amputation of the thigh. In sawing the bone so high, however, some precaution is necessary, as the synovial membrane of the knee-joint sometimes descends a little over the front of the tibia. The ligament of the patella ought also to be spared both on its own account, and on that of the bursa mucosa which is placed behind it.

Circular method.—In the application of this method, the convenience, to the operator, of laying hold of the upper part of the limb regulates his position, either on the outside or inside of the limb. In general, he places himself on the inside; but he may also place himself on the outside, particularly if the right leg is to be amputated. The position on the inside of the limb is recommended, because in using the saw from that side, the fibula is first divided. As regards the section of the bones, this may be an advantage; but the division of the soft parts is matter of greater importance, and the rule ought to be to have the left hand above the section.

The circulation is commanded by an assistant, either with a tourniquet applied over the femoral artery in the usual situation, or with his fingers, a hand pad, or key, against the pubis. Compression of the artery in the popliteal space is uncertain.

The patient is placed on a table, or on the edge of a high bed; the limb to be removed is confided to the hands of another assistant.

The first incision commences on the outside of the spine of the tibia, is carried over the fibula, and terminates on the inside of the first bone, joining the point from which it set out. (*d, c*, no. 2, figs. 42, 43). The skin is dissected up for an inch and a half, and reflected, the fat outwards, so as to form a *bourrelet*, or sleeve. The second, proceeding as the first, divides the muscles, front and back of the bones, at the point where the skin is reflected. The interosseous muscles, with all the parts below the level on which the soft parts were divided by the second incision, still remain, and can only be cut by carrying the catling round each bone separately. As soon as this step is completed, a three-tailed linen compress is used to retract the divided muscles, &c., and the saw is applied first on the tibia, and then on the fibula, or rather on both together, and taking care to complete the section of the fibula first. Within the last thirty years, surgeons both in England and on the Continent have been in the habit of removing the spine of the tibia, which from its extreme prominency, is sometimes liable to become denuded in the stump. Beclard used to direct the first strokes of the saw upon it obliquely from above, downwards, for about half an inch above the point at which he intended to saw the bone transversely; he then withdrew the saw, and commencing the section below, so as to fall in with it, cut through both the bones in the manner already described. Messrs. Guthrie and S. Cooper, recommend this practice; but they do not insist upon it, perhaps, so much as it deserves.

The difference in the degree of retraction which the muscles in this part of the limb present in consequence of their being attached to bones, or free from such attachment, has suggested certain modifications in the manner of dividing them. The muscles situated in the hollow between the tibia and fibula, anteriorly retract but little: those situated behind the bones retract in proportion to the length of their fibres, and their freedom from attachment to bone. Sir C. Bell, keeping these points in view, recommends, first, an oblique section of the gastrocnemii muscles upwards, and then the complete division of the less retractile muscles on a level with the top of this incision. B. Bell, with the same object, repeats, for this amputation, the same caution that he gives in regard to the thigh and arms, viz. to detach the muscles for some way up the bones before applying the saw.

The arteries that will require a ligature are, the anterior tibial, which will be found in front of the interosseous ligament, associated with its nerve, and from which it must be separated before the ligature is applied; the posterior tibial artery; the peroneal; the gemelli, and sometimes the nutritious artery of the tibia. The arterial distribution here varies according to the height on the limb, at which the amputation is performed. When the operation is performed as high up as the tuberosity of the tibia, there will be but a single trunk to tie, the popliteal, with some articular branches, and the gemelli; in proportion as the bones are cut lower, we shall have the nutritious artery of the tibia, the posterior tibial, and the peroneal.

The lips of the wound are made to cover the bones either transversely or in a line from front to back. Richerand recommends an oblique reunion in the line of the two bones, a mode which combines the advantages of the other two. The stump should be slightly bent, and made to rest on its outer edge on a cushion.

Fig. 44.

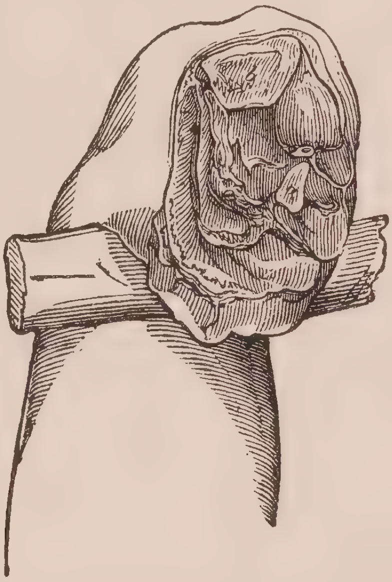


Fig. 44. *Circular amputation of the left leg at the place of election; the leg is represented, supported by a rail, with the face of the stump turned forwards, in the position it is usually presented in amputation, when the bleeding vessels are about to be tied. The tibia (marked b), and the fibula (marked a), are seen in the soft parts a little nearer to each other than natural, owing to the latter's having lost its support; the knee, and upper part of the leg are but little seen, being foreshortened in order to afford a fuller view of the face of the stump.*

Flap method.—This method, though first applied by Lowdham to amputation of the leg, is rarely resorted to by modern surgeons, except in cases where it presents the only alternative to an amputation of the thigh. It has numerous modifications; some surgeons form two flaps; others but one. Dupuytren used to form two flaps, the front one extending three inches down the tibia, the back one of the same extent, behind the bones; both were joined, according to Ravaton's plan, by a circular incision, and the flaps were dissected up to their base. The muscles of the interosseous space are then cut clean, and the bones are sawed in the usual way.

In Lowdham's plan, a single flap four inches long from the point where the bones are to be sawed, is formed out of the soft parts of the calf; the skin and interosseous muscles on the front or outside of the leg are divided by a transverse incision. The inconvenience, and frequently the excessive pain arising from the sudden turn which the base of the flap must make to cover the bones, render the operation by single flap ineligible, whenever it can be avoided. The oval method will obviate this objection, and ought to be preferred.

The *oval method* consists in an oval incision of the integuments, which are dissected and reflected back to the extent of two inches; and in a circular division of the muscles.

KNEE-JOINT.

The question of *amputation at the knee-joint* has been long regarded by the generality of surgeons as finally settled. Numerous successful cases, however, in which this operation has been resorted to of late years, either from necessity or the individual views of the surgeon, have again brought it under consideration. Some very eminent practitioners have thought that the amputation of the leg at the knee-joint has been too indiscriminately proscribed, while others, going still further, blame the timidity that has prevented surgeons from boldly penetrating into large articulations, and assert its superiority over amputation as performed in the continuity of the bones, either of the leg or thigh. The arguments against amputating in joints, especially of large size, have been laid down in the first division of the present article, and though we still adhere to our objections to these amputations, unless as exceptional proceedings, where an unusual prospect of success, or an unusual necessity might justify us in deviating from what we deem a safer course, still we see no reason against briefly stating the arguments of those who consider that this operation has been too lightly condemned.

They affirm, that so long as the periosteum of a bone, or the articular cartilage covering a bone, is uninjured, that no bad consequence can arise from exposure to the air, as these coverings afford a perfect protection against inflammation; that there is no synovial membrane spread over the cartilages; that it is almost always possible to save a sufficient quantity of the surrounding integuments to form a good and ample covering for the exposed condyles; that the wound is not so large as some imagine, the flap being formed almost exclusively of integument, which adheres most readily to the condyloid surfaces; and finally, that the disarticulation of the leg leaves not only a good stump, but that it preserves the mobility of the head of the thigh-bone in the acetabulum, which is lost when the amputation is performed in the continuity of the femur. When the amputation is performed at the knee-joint, the individual walks with an artificial leg, as if he had a stiff knee. But when the thigh is amputated, progression is by no means so free: he walks as if the head of the thigh-bone was ankylosed. The surgeon will make his own estimate of these arguments. The operation is performed in different ways, according to the method preferred.

AMPUTATION AT THE KNEE-JOINT.

Circular method.—An incision round the limb, at the distance of three or four fingers' breadth below the patella, divides the skin and subjacent adipose tissue down to the muscle, (*x*, *y*, fig. 42, or *f*, *e*, fig. 43); it is dissected up, and turned upon itself like a sleeve; all the thickness of the adipose tissue must be preserved to it. An assistant draws it upwards towards the joint; the ligament of the patella is divided, and the knife enters the articulation, cutting the lateral ligaments. The joint is now thrown open, the semilunar cartilages are detached, and the crucial ligaments cut. The operation is terminated by cutting down, at one stroke, all the soft parts of the ham, to the edge of the circular incision first made through the integuments. The popliteal artery, and any other small vessel that may give blood, are then secured; the parts are sponged clean, and the lips are brought together transversely, or in the direction of the large diameter, from one condyle to the other. They may also be united from front to back, in which case, the cicatrix would be shielded from pressure against the artificial leg, as it would thus be made to correspond to the depression between the condyles.

The circular method will in general be found to be the best; but cases may occur where, in consequence of disorganization of the integuments, it will be impossible to obtain a sufficient covering by any other than the flap method, which may be had recourse to, with one or with two flaps, according to circumstances.

With one flap.—Hoin used to perform this operation by extending the limb, and making a semilunar incision of the integuments, below the patella, beginning below the condyle on one side, and terminating at the other. The second stroke opens the articulation, cutting the lateral and crucial ligaments. The knife then turned on the flat, on the back of the tibia and fibula, cuts out the flap from the muscles and integuments of the calf. The danger of a denudation of the bone in this mode is much greater, as is also the difficulty of making and maintaining proper coaptation of the lips of the wound.

Fig. 45.

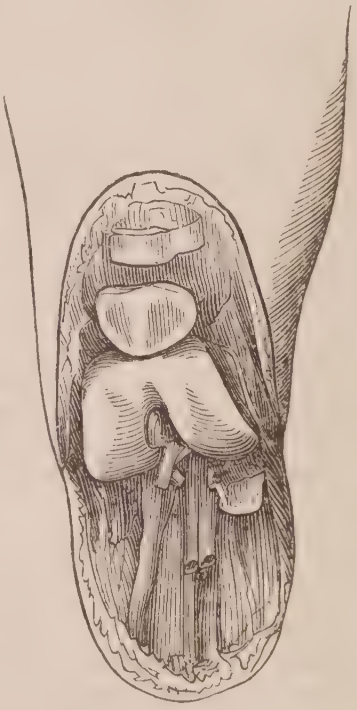


Fig. 45. *Amputation by double flap at the knee-joint; the anterior flap, containing the patella is reflected upon the thigh; the posterior flap containing the popliteal artery, vein, and nerve, is hanging down.*

With two flaps.—This proceeding, first resorted to by Mr. Smith, may also in certain circumstances be preferable to either the circular or the single flap method; for instance, where the soft parts on the back of the leg are so damaged that a single flap of the required length to cover the condyles completely cannot be obtained from them.

The oval method has also been proposed; but this as well as the flap method should merely be considered as modifications to be kept in reserve, and only to be had recourse to in particular cases.

THE THIGH.

The muscles of the thigh, like those of the arm, may be arranged into three classes also: the muscles that connect it with the trunk; those that stretch along it, without attachment, and are inserted into the bones of the leg; and those that cover and are attached to it. The form of the limb is somewhat conical, owing to the gradual diminution of the mass of the soft parts, from the trunk to the knee.

Possibly all the advantages of amputating at the knee-joint might be secured, and the objections obviated, by resecting the condyles in the spongy head of the bone, thus converting it into an amputation in the continuity, at the lowest possible point of the bone.

The muscles, as regards their retractility, may be arranged into two layers, a superficial, and a deep-seated one. The great length of the superficial muscles, and their freedom from attachment between the two points of their origin from the pelvis and insertion into the bones of the leg, favour their retractility in the highest degree. It will be obvious, therefore, that the lower down the limb the superficial muscles are divided, the greater will be their retraction. If then, in amputating the lower third of the thigh, we are to begin our circular incision four fingers' breadth below the point at which the bone is to be sawed, the application of the same rule in amputating at the upper part of the limb must rest upon a different principle. If the greater retractility of the superficial muscles, when divided at the lower part of the limb, requires the space of four fingers' breadth between the first section of the integuments and that of the bone, the greater bulk and depth of soft parts, and the consequently greater difficulty of properly confronting them in order to their reunion, will also render it necessary above. The principle, therefore, that regulates circular amputation, viz., to cut the layers in succession from the skin to the bone, each at a higher point than that of the layer last cut, and the bone itself highest of all, is specially applicable in amputation of the thigh. The retraction of the muscles will also be augmented, for those muscles which may, from the position of the limb, be thrown on the stretch during the performance of the amputation. When the stump is finally healed, this greater power of retraction in the superficial muscles has a direct influence on the position of the cicatrix, which is drawn inwards and backwards by the more powerful adductor muscles.

As there is no place of election for amputating the thigh, the rule of preserving as much as the disease or injury has spared, and of amputating as low down as possible, remains in full force. The danger of the operation in these cases, diminishes in proportion to the smallness of volume of the soft parts.

AMPUTATION OF THE THIGH.

Circular method.—The patient being placed on the edge of a bed, or on a table, the assistants, to the number of four or five are disposed in such a manner as to support the head, pelvis, and the sound limb; one takes charge of the leg to be amputated, supporting it on his knee, or a low stool, according to circumstances; another stops the circulation in the femoral artery, either with his fingers or a tourniquet. It is unnecessary to repeat the motives mentioned in the first part of this article for preferring, except under particular circumstances, the intelligent pressure of the fingers. The point of resistance against which the artery should be pressed is the pubic bone, where the vessel passes over it. Whenever the tourniquet is employed, it should be placed as high up the limb as possible. The instruments are placed in a tray within the surgeon's reach, or they may be handed to him according as they are required by an assistant.

The thigh being grasped firmly above the point where the incision is to be made, the skin and muscles are drawn upwards, and thus rendered tense and steady. The surgeon, standing on the outside of the limb, carries the knife to the inside of the thigh, the handle firmly grasped in the right hand, the point directed towards himself, and then at one sweep round the limb, beginning the cut with the part of the blade next the handle, divides the skin and adipose tissue down to the fascia. The incision penetrating beyond the fascia, is not a matter of importance, but it ought to divide the adipose tissue down to the fascia. The skin and adipose tissue are then retracted by the assistant, and if any bands oppose their ascent they are to be cut. Some surgeons, however, still adhere to the old plan of dissecting the skin up to the extent of an inch or more, and then retracting it, before they begin the section of the muscles, a plan which is more especially eligible when the amputation is performed in the upper and thicker portion of the limb.

Another circular incision, made at the line to which the skin is retracted, divides the superficial muscles; these being retracted in their turn, the deep-seated layer is exposed, and cut by a third circular sweep of the knife. A two-tailed linen retractor is next applied; the tails are crossed upon the cut surfaces, above the bone, the muscular fibres still adhering to the bone are cleanly cut, and the operation is terminated by sawing it four inches higher up than the point at which the skin was cut.

The lower the point at which the amputation is performed, the fewer will be the vessels requiring a ligature. At the lowest point, viz., four fingers' breadth above the condyles, the vessels requiring attention are the femoral artery, the anastomatic (*ramus anastomaticus*), with perhaps a few muscular branches which may be twisted. At the upper part of the limb, there will be, besides the femoral artery, the profunda, branches of the circumflex, obturator, and ischiatic arteries, and perhaps some muscular branches.

Fig. 46.

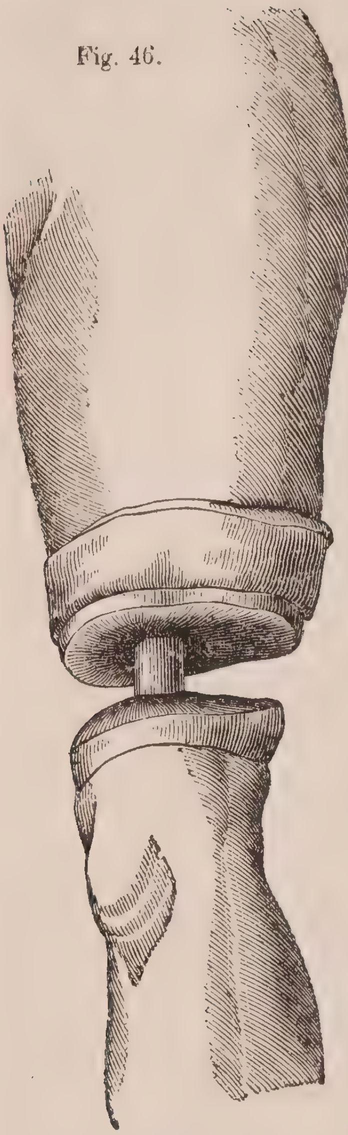


Fig. 46. *Circular amputation at the lower third of the thigh; the skin which was cut at the line just above the knee is seen reflected like a sleeve upon the middle part of the thigh. The muscles are divided down to the bone; and the operation is advanced to the point at which the retractor is to be applied, and the bone sawed through.*

The large nerves in the thigh, not being retractile like the muscles, are sometimes seen after amputation hanging, or projecting from the surface of the muscles. If left in this state, they render the dressing painful, and the stump less useful after the healing process is completed; it will, therefore, be better to snip them at once to the level of the muscles with a very sharp pair of scissors, or cut them with a quick stroke of the knife.

The sides and lips of the wound are brought together, on a line from one side of the thigh to the other, or from the front to the back. The transverse line of union is that usually preferred by the surgeons of this country. The French surgeons, who resort less frequently than ourselves to healing the wound by first intention, prefer the antero-posterior line of union, as the pus has a better drain from the posterior angle. Some surgeons unite the lips of the wound in an oblique line from without inwards and backwards, imagining thereby that they avoid the inconveniences of the two former modes of confronting the wounded surfaces.

Fig. 47.

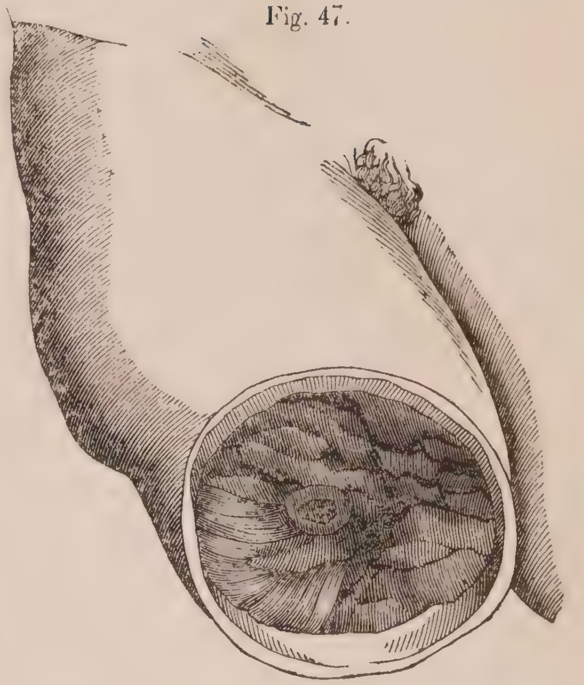


Fig. 47. *Circular amputation at the upper and thickest part of the thigh.*

Flap method.—In the general description of this method, already given in the first part of this article, will be found the details of its application to the thigh. It may be doubted whether the flap method for this particular amputation, really possesses any of the advantages ascribed to it. At the upper part of the limb, however, its superiority over the circular method is manifest from the greater facility it affords for confronting the surfaces of the wound. It is executed certainly with more rapidity, especially in young subjects, or when the limb is wasted; but those surgeons who disapprove of its application, except in cases of necessity, maintain that it is more painful, and that it involves a greater extent of the soft parts in the wound.

Fig. 48.

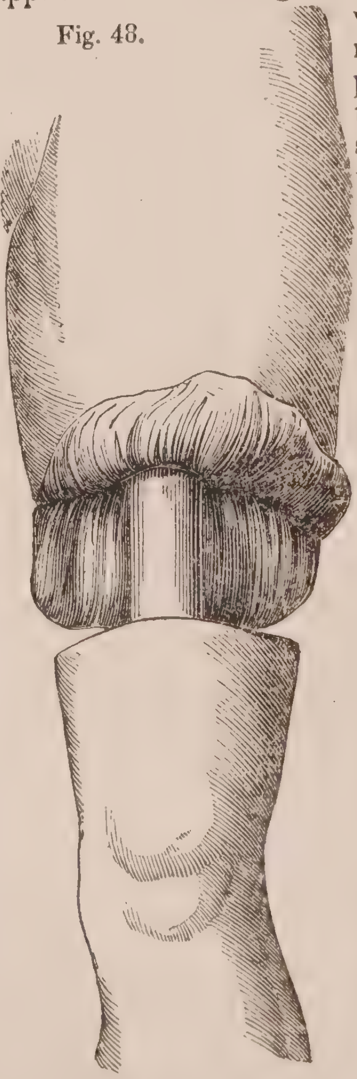


Fig. 48. *Amputation, by double flap, anterior and posterior, at the middle of the thigh. The shaft of the bone is bared to the extent of three or four inches, the length of the flaps. The operation is advanced to the point where the retractor is to be applied, and the bone sawed through.*

HIP-JOINT.

If the danger attending an amputation, be *cæteris paribus* in proportion to the volume of the parts through which the section is made, then is the amputation of the thigh at the hip-joint the most formidable that can be performed, buried as that joint is to a considerable depth, and surrounded on all sides by such a large mass of soft parts. These considerations very naturally deterred surgeons from attempting such an extensive mutilation, and it was only as the art made progress, and the principles on which success mainly depends became better understood, that the proposal for amputating at the hip-joint began to be entertained as a rational undertaking. Morand, it would appear, was the first who ventured to express an opinion on the possibility of its success; an opinion which was brought formally under the notice of the Academy of Surgery by two of his pupils, Wolher, a surgeon in the guards of the king of Denmark, and Pacthod of Nyon in Switzerland, in the year 1739. The Academy in the following year received a favourable report on the Memoir of these surgeons, drawn up by Ledran and Guerin. Encouraged by the discussion, Ravaton was on the point of putting the proposed plan in execution, in a case of fracture of the great trochanter and neck of the femur from a gun-shot, and was only driven from his determination, by the adverse opinions of the surgeons with whom he consulted on the occasion. Lalowette made it the subject of a thesis, which was defended by Vallum in 1748. The subject seeming to several of the members of the Academy to be entitled to further investigation, it was made a prize question at the instance of Morand in 1756, and again in 1759. None of the essays on the first occasion were found worthy of the prize, which, on the second, was awarded to Barbet, who forcibly advocated the propriety of the operation, and pointed out the cases to which he considered it rationally applicable.

The question was propounded by the Academy in the following terms:—"*In the case in which amputation at the hip-joint should appear to be the only resource for saving the patient's life, to determine whether this operation ought to be practised, and what would be the best mode of performing it.*" Thirty-four essays were presented, including Barbet's, almost all of which, besides several other dissertations on the same subject, by Goursault, Moublet, and others, maintained the practicability of the operation, from experiments on the dead subject, or on dogs.

Notwithstanding the great encouragement thus held out, no one was bold enough to undertake the operation for a considerable time afterwards. True it is, however, that some cases had occurred in which gangrene having first made extensive ravages round the joint, the disarticulation of the thigh bone had been artificially effected; but this process, though it might be regarded as an encouragement, could not be taken in any sense as the equivalent of the amputation at the hip-joint, strictly so called.

Familiar as the discussions of the Academy must have made the minds of the French surgeons with the subject, it seems not a little curious that the first case in which it was performed is recorded of an English surgeon, Mr. H. Thomson, surgeon to the London Hospital. Pott was strongly opposed to the operation, and censures, in the following passage, its performance in the case which he had himself witnessed:—"That the amputation in the joint of the hip is not an impracticable operation (although it be a dreadful one) I very well know. I cannot say that I have ever done it, *but I have seen it done*, and am now very sure I shall never do it, unless it be on a dead body. The parallel which is drawn between this operation and that in the shoulder will not hold. In the latter, it sometimes happens, that the caries is confined to the head of the os humeri, and that the scapula is perfectly sound. In the case of a carious hip-joint this is never the fact; the acetabulum and parts about are always, more or less, in the same state, or at least in a distempered one, and so indeed most frequently are the parts within the pelvis." Mention of the second instance, in which it was put in execution in this country, occurs in the sixth volume of Duncan's Medical Commentaries, published in 1779. The operation was performed by Kerr, of Northampton, on a girl between eleven and twelve years of age. It would appear from Pott's censure on the first case, and from the description of Kerr's case, that in both these instances, the operation was resorted to for disease of the joint. The result in both cases was of course unfortunate, as the removal of the limb could have no effect in arresting the progress of the disease. In Kerr's case, the acetabulum and surrounding part of the os innominatum were carious, and there was extensive tuberculization of the lungs.

It was soon perceived that the analogy between amputating for scrofulous disease of the knee-joint in the continuity of the thigh, and disarticulating the head of the femur from a diseased acetabulum did not hold good. In most of the subsequent attempts, therefore, the operation was restricted to the cases in which Barbet had described it to be applicable, viz.: Where by sudden violence, as from gun-shot wounds, or crushing by machinery, a healthy bone is extensively injured at its head, neck, or upper part; where the limb is carried away by a cannon-shot close to the trunk; or where gangrene has so far extended, or threatens to extend, its ravages, as to render it impossible to obtain a sufficient covering for the stump by any other means. To these, as the principal cases in which this amputation is likely to be attended with a favourable result, may be added, lesions of the bone high up, from comminutive fracture, caries, necrosis, osteo-sarcoma, spina ventosa, or other incurable alterations beyond the reach of extirpation, by an amputation in the continuity of the femur.

When resorted to in this description of cases, some years later, it was successful. M. A. Blandin, a surgeon in the French republican army, in the third year of the Republic, operated successfully on a soldier. In a second case, he was equally fortunate ; and, in a third case, the patient survived the operation fifty-eight days. The operation was again successful in the hands of Perret, another military surgeon ; and, in 1798, Mulder performed it, with similar good fortune, on a girl of eighteen years of age. About the commencement of the present century, Larrey had already operated in two cases during the Egyptian campaign. Since that period it has been performed many times in different countries, and successfully too in a good many cases. Dr. Millingen is said to have operated successfully in two cases. Mr. Brownrigg was successful in the case of a soldier who was wounded at Merida, in 1812. This man was since, and perhaps is still, resident at Spalding in Lincolnshire. Mr. Guthrie successfully amputated the thigh at the hip-joint of a French prisoner, who is still living in the Hôpital des Invalides, at Paris. Delpech, Orthon, Mott of New York, Wedemeyer, Syme Brice, Sir A. Cooper, and lately Mr. Mayo, have each had a successful case. It would not be an easy matter to determine the proportion of the successful to the unsuccessful cases; but the reverses also are numerous. In 1812, Baffos, at the Hôpital des Enfans, lost a child seven years old, not in consequence of the operation, which, as was before observed, is not indicated in the scrofulous affection of the hip-joint, but from the progress of the disease. The little patient survived the operation three months : the acetabulum was diseased. Mr. Carmichael performed the operation in the year 1819, at the Richmond Hospital, Dublin, on a young woman of nineteen, for an osteo-sarcoma. The writer of this article, then a pupil of Mr. Carmichael's, was present. The operation was performed with great celerity ; the patient lived only till the fifth day. The operation, even in the cases in which it is indicated, has failed in the hands of some of the most eminent surgeons of the day, amongst others, Sir A. Cooper, Sir B. Brodie, Dupuytren, Mr. Guthrie, Baron Larrey, Blick, Cole, Delpech, Dieffenbach, Emery, Gensoul, Clot-Bey, Roux, and Pelikan of Wilna.

Various points have been indicated as guides to the articulation ; of which, in order not to embarrass the memory, we shall select only the most important. The great trochanter is easily felt ; it takes a direction upwards, inwards, is turned a little backwards, and forms a prominence about half an inch or a little more above the neck of the femur. The small trochanter projects about half an inch from the inside of the bone, at a nearly right angle from its axis, and is continuous with the lower part of the shaft, at an angle inclined upwards of 50° with the axis of the bone. If the patient be placed recumbent, the tuberosity of the ischium will be an inch and a quarter in advance of the acetabulum.

Again, if a perpendicular line be drawn from the anterior inferior spinous process of the ilium, the outer or anterior part of the joint will be about half an inch to the inside of the inferior extremity of this line. The articulation is most superficial in front, and corresponds with a line which would bisect Poupart's ligament, at the union of its outer with its two inner thirds.

The disposition of the capsular ligament deserves to be noticed : the head of the bone, which is nearly spherical, is not entirely sunk in the articular socket; the capsular ligament, springing from the rim of the acetabulum, covers the outer portion of the bony sphere, and shrinks in ampleness, as the bone diminishes in size, to form its neck. If, therefore, the surgeon were to cut the capsular ligament low down on the neck of the bone, instead of dividing it round the edge of the acetabulum, the head of the bone being much larger than the opening made for its passage would remain locked in the cotyloid cavity. The internal or round ligament is easily thrown on the stretch, and even brought to the edge of the acetabulum by carrying the limb outwards. The same observation respecting the incomplete ossification of the epiphysis of the long bones may be repeated here. Up to the age of ten or twelve years, the great and small trochanter, and even the head of the femur itself are so soft that they may be easily cut with a knife, and the surgeon should be prepared to turn this circumstance to account on an occasion.

In front, the articulation is more superficial than at any other point, being here separated from the skin only by the psoas and iliacus muscles, by the rectus externally, and by the great vessels, but at some distance, internally. Behind, and on the inside, the muscular mass is very considerable. The depth of the articulation from the trochanter on the outside is considerable, but when the bone is removed there is little left to cover the acetabulum beyond the skin alone. Upon these points, therefore, must the formation of the flaps be regulated. As in the case of the disarticulation of the shoulder-joint, the amputation at the hip-joint is performed by all the various methods, or by processes combined from them, according to the necessities of the case, or the genius of the operator. We shall describe the principal modifications only.

AMPUTATION OF THE THIGH AT THE HIP-JOINT.

Flap method.—The operation is performed with a single or double flap. When two flaps are formed, they are cut in such a manner as to form an anterior and posterior, or two lateral flaps; the other modes of forming the flaps are but variations of these.

With two lateral flaps, or an outside and inside one.—In some of the early descriptions of this method, it is recommended, as a proper precaution against hæmorrhage, to tie the femoral artery, close up by Poupart's ligament, and above the origin of the circumflex and profunda. Larrey makes this the first step of the operation, (I, II, III, 1, 2, 3, figs. 42 and 43,) and the practice has the approval of Blandin, who thinks, that as the artery is easily secured, and the hæmorrhage from so large a vessel would be so quickly fatal, that it will be more proper, rational, and prudent, to begin the operation by placing a ligature upon it. Others, on the contrary, dissent from this doctrine, regarding it as an additional and a superfluous operation, and rely on the compression made on the trunk of the artery with a pad, or the fingers of an intelligent assistant, against the horizontal branch of the pubis. Cases, however, may occur, where the exhaustion of the patient is so great, that it becomes imperative to secure him against all mischances, and under such circumstances, it would be improper to slight this precaution.

But whether the artery be first tied or not, the patient is placed on his back, the pelvis supported by a pillow, and advanced to the edge of a bed or table. The surgeon places himself on the outside of the limb, and plunges a long slender knife into the upper part of the thigh, in a direction from front to back, so that the blade shall graze the bone just between the upper edge of the trochanter minor, and the root of the neck of the femur. The knife is urged on in the same direction until its point comes through the skin at the opposite surface of the limb; the edge of the knife is then directed downwards, and inwards, and keeping close to, but clear, of the small trochanter, and an internal flap about four inches long is made with a quick and even sweep of the knife. The flap is raised towards the opposite thigh, and the limb being carried a little in abduction, one-half of the capsular ligament is cut close upon the brim of the acetabulum, the edge of the knife being directed in the same manner as if the surgeon wished to cut off the spherical head of the bone through the middle. The movement of abduction is augmented, and the internal ligament being thus made tense against the head of the femur, is easily divided. The head of the bone being now drawn down, the knife is turned round it, and the other half of the capsular ligament is cut. The tendons of the gluteal muscles are cut through, close to the outer and back part of the great trochanter, and the knife is carried outwards and downwards, so as to form an external flap, similar to the internal one.

When the femoral artery is previously tied, the first flap incision should proceed from the inferior angle of the wound inflicted for that purpose; and, again, when the knife has doubled the head of the bone, it should be brought down the outside of it, until it falls again into the preliminary wound, and it is then carried outwards and downwards to form the external semicircular flap.

With an anterior and posterior flap.—Mr. Guthrie's method of forming the flaps differs from that just described in regard to the point from which the incisions proceed, and their direction. He first divides the integuments only, on the inside and then on the outside of the limb, from a point in front of the spinous process of the ilium, to another, close by the tuberosity of the ischium, where the two incisions join again (*o*, *p*, *q*, and *h*, *o*, *n*, figs. 42 and 43). The skin is reflected up, and the muscles are cut at the point of retraction, obliquely upwards towards the articulation. The two flaps thus formed are provided with an ample covering of integument, and may be described as internal and anterior, and external and posterior. Mr. Guthrie does not tie the femoral artery in the first instance as Larrey does, and his mode of operating differs only from that recommended by Beclard, in the incision and retraction of the integuments, and in cutting the muscles from without inwards, instead of plunging the knife in at each side of the head of the bone, and then cutting outwards. One obvious advantage obtained by proceeding according to Mr. Guthrie's plan, is, that it leaves more integument and less muscle in the wound; and, in one of such extent, this is a consideration of no small importance.

Dupuytren used to form the internal flap by an incision, first, of the integuments, and then of the muscles upwards to the joint; he made the outer flap with one incision.

With a single flap.—This method is well described in one of the early theses on this subject by De Vallun:—The patient lying on the sound hip, the operator makes a transverse semicircular incision, from the upper part of the great trochanter to the tuberosity of the ischium, dividing at once all the parts down to the joint. (9, 10, fig. 42; 4, 5, 3, fig. 43). The limb is now rotated inwards, the outer and back part of the capsular ligament is cut, and the round ligament, with a probe-pointed bistouri. The limb is brought a little downwards, and the rest of the capsular ligament being cut, a flap four or five inches long, according to the volume of the limb, is formed from the flesh on the inside of the thigh. Manec, and Ashmead, of Philadelphia, have proposed reversing the steps of this proceeding, forming the inner-flap first, cutting from without inwards and upwards, then disarticulating the head of the bone, and cutting outwards.

When the femoral artery has been tied, previously to the formation of the flaps, the operation is terminated without stopping to secure the other bleeding vessels.

Lisfranc's plan; an external and internal flap.—This able operator, it is said, can complete the amputation in the hip-joint, on the dead subject, in ten seconds. He makes use of a long, thick, two-edged knife or catling. The limb being extended, and held, if possible, in a position between adduction and abduction. He recognizes, by drawing a perpendicular line, from the anterior superior spinous process, down the thigh, and another line, half an inch directly inwards towards the pubis, the spot on which he is to commence his incision. Placing the point of the knife on the end of the transverse line, he pushes it perpendicularly downwards, grazing the outside of the head of the bone, until it comes out a few lines lower than the tuberosity of the ischium. It is necessary, as soon as the point of the knife reaches the bone, to incline the handle upwards and outwards, in order to turn its point fair for the tuberosity; this manœuvre is facilitated by the surgeon or an assistant's taking hold of the flesh of the gluteal region, and carrying it, *en masse*, towards himself. As soon as the knife has passed completely through from front to back, the lower edge is inclined outwards and downwards, cutting about an inch in that direction, until it clears the great trochanter. This division is effected more with a sawing than a cutting motion; the knife then glides from the bone, obliquely, through the muscles, forming an external flap, four or five inches long.

Fig. 49.

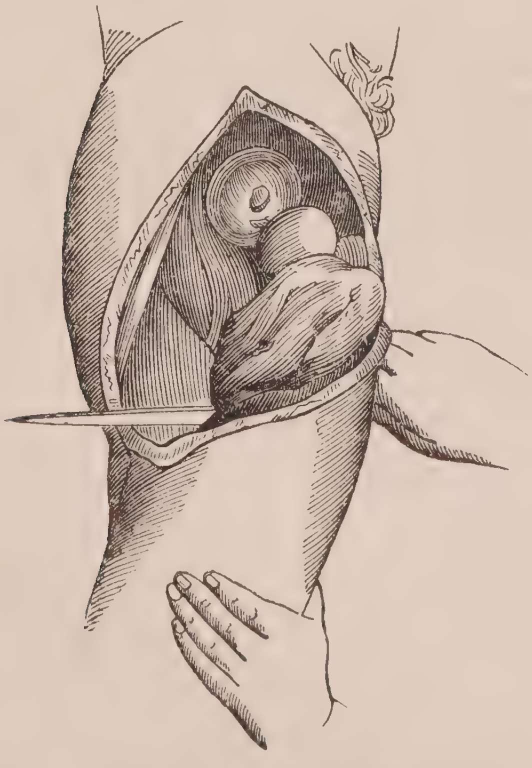


Fig. 49. *Amputation of the thigh at the hip-joint; the external flap has been formed; the head of the bone disarticulated from the acetabulum, and the knife carried to the inside of the femur has fallen into the line of incision for forming the first flap, and is now forming the second flap from the soft parts on the inside of the thigh.*

An assistant now takes hold of the flesh on the inside of the limb, and draws it towards the opposite thigh; and the surgeon placing the point of his knife again in the upper angle of the wound, inclines it slightly inwards, carrying the blade a little beneath, and to the inside of the head of the bone, so as to make it fall into the line of the first incision, and avoid wounding the integuments. He then cuts down the bone to the small trochanter, following this prominence with the edge of the knife; at this moment he directs one of the assistants to make compression on the femoral artery, by seizing the base of this second flap between his fingers and thumb; and he then terminates the internal incision, leaving the flap of the same length as the external one. The vessels are tied, and the head of the bone is disarticulated in the manner before described.

In Lisfranc's, and the other plans which resemble it, as to the formation of the internal flap, the facility of effectually compressing the artery in this flap, before the edge of the knife is turned outwards and downwards, is so great, that the preliminary operation of placing a ligature upon it may be safely dispensed with. As soon, however, as the internal flap is formed it may be tied. The flow of blood from the other vessels may be temporarily stopped by the fingers of assistants applied over them. Some surgeons, however, tie the arteries as the operation proceeds. Besides the femoral artery, the obturator artery, branches of the pudendal, ischiatic, and gluteal arteries will require torsion or ligature.

Circular method.—Mr. Abernethy, who advocated as far back as the beginning of the present century, the propriety of compressing the femoral artery against the horizontal branch of the pubis instead of placing a ligature upon it before the operation, was the first to propose, in his surgical lectures, the performing this amputation by circular incision. He used to make the first incision of the integuments a few inches below the articulation; the muscles were divided higher up, at the point to which the skin was retracted, and completely detached from the great and small trochanter. The capsular and the round ligament were then cut, and the limb removed. This method was adopted by Mr. Colles, in the case of the patient upon whom he operated, and by Krimer in his case.

Græfe also shows the same preference for the circular method in the amputation of the hip, which he gives generally to amputations in the contiguity. He performs the operation with his large knife, the blade of which is enlarged and rounded off at the end. He thinks this form of knife enables him in cutting the muscles, to hollow out the cone better. He divides the soft parts from without inwards, or rather from below upwards towards the joint. He avoids the difficulty which might be felt in disarticulating the head of the femur, by cutting the capsular ligament at the under part, where the brim of the acetabulum is imperfect. This difficulty is, however, easily obviated by observing the rule already given, of cutting the capsular ligament in the same manner as if the operator intended to leave half the head of the bone in the socket. Mr. S. Cooper mentions a case where, from neglecting this point, a very eminent surgeon was unable for half an hour to disarticulate the head of the bone from the acetabulum. Dr. Veitch is also in favour of the circular method. When the muscles are detached from the trochanters, he advises the detachment of the muscles for some little way down the limb, for the purpose of using the bone thus cleared as a lever to facilitate the separation of the head from its articular socket. This step is quite unnecessary, and causes delay.

The oval method proposed by Scoutetten, Cornuau, and Mr. Guthrie, though frequently executed on the dead body, has not as yet been resorted to in the case of a living person. It is thus described :—the patient lies on the sound hip, and the limb is supported in adduction by an assistant. The first incision is made from an inch above the great trochanter, and descends obliquely forwards to the anterior part of the thigh, to the extent of six or eight inches, if the patient be an adult. This incision terminates at a point at which a perpendicular line from the superior spinous process of the ilium, would cross another line drawn transversely from the tuberosity of the ischium, and divides the integument, and the muscles down to the bone. Another oblique incision of the same length is carried from above the head of the femur downwards and backwards to a little below the tuberosity of the ischium. The joint is thus freely exposed ; the capsule and the internal ligament are divided ; the head of the bone is luxated outwards ; the knife is carried to the inside of the neck of the bone. The assistant now compresses the femoral artery by inserting his thumb and fingers into the wound, and the operation is terminated by cutting downwards and inwards all the soft parts on the inside of the thigh, so as to unite the two extremities of the inverted V formed by the two first incisions.

Fig. 50.

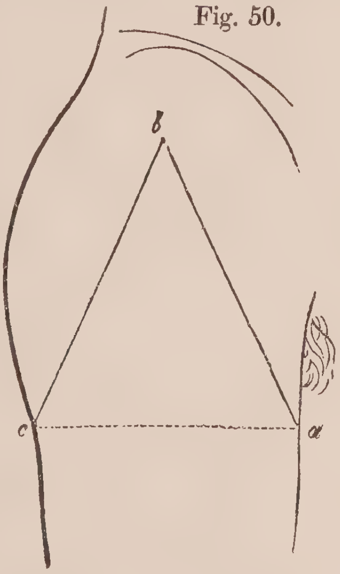


Fig. 50. *The lines of incision for amputating at the hip-joint by the oval method, as proposed by Scoutetten and Cornuau.*

The numerous methods proposed for amputating the thigh at the hip-joint have not originated solely in the comparative facility of performance : the very nature of the injury may create a necessity for proceeding in a given way, and exclude the exercise of choice or preference ; and hence it is, that though one mode of proceeding may, in a general sense, be more advantageous than another, they must all be retained as resources for special cases.

The majority of the amputations hitherto performed at the hip-joint have been executed according to the flap method, or some of its modifications. This preference seems to have been accorded, both on account of the great bulk of the limb itself, and the anatomical configuration of the articulation. If the flap method is preferred in amputating the thigh high up near the trochanters, how much stronger must be the reasons for the preference, when the operation is to be performed in the articulation itself! But in the flap method as applied to this operation, there are certain modifications more or less favourable. The flaps which contain most skin and least muscle are the best ; as the liability to inflammation and extensive suppuration will be least in flaps so formed. This is one excellence of the mode of proceeding recommended by Mr. Guthrie and Dupuytren. The anterior and posterior flaps, when the state of the soft parts will allow of their being made of equal length, are most readily adjusted ; and when the parts are extensively injured, as the integuments are divided by a separate incision, an adequate quantity of them may be preserved with very little of the muscles. The oblique position of the flaps would also give greater facility for filling up the deficiency occasioned by the removal of the head and neck of the thigh bone.

The same advantages do not attach to the method when performed on the plan of Larrey, Lisfranc, &c. The external flap cannot be made sufficiently full, and ample to correspond with the internal one, and most commonly it will be either so irregular or deficient at its posterior part as to require points of suture to maintain it in coaptation.

When the accident has spared only enough of the soft parts to form a single flap, there is no room for choice ; it must be formed as best it may. If the parts on the anterior and internal region of the thigh are sufficient, the plan of Manec and Ashmead will afford the best result ; the section being made from without inwards, and the skin being divided first, a flap ample of skin and scant of muscle is thus procured. Velpeau, in a case in which he adopted this plan, describes the flap as covering the wound without effort, and remaining properly applied as it were, by its own weight.

The oval method is of very easy execution, if we may be allowed to judge from what we observe on the dead subject ; but the covering it leaves at the upper part of the wound, where the excavation of joint is to be filled up is rather scanty. This inconvenience might be obviated by making the incisions somewhat after the manner Larrey amputates the shoulder-joint.

The circular method is the most difficult of execution, and the least advantageous of all, for amputation of the thigh in the articulation.

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(*T. King.*)
(*W. B. Costello*[1].)

AMYLUM, Lat.; *ἄμυλον*, (from *α* priv., and *μύλη*, *a mill*, being prepared without grinding), Gr.; *Stärke*, *Satzmehl*, Ger.; *amidon*, Fr.; *starch*, Eng. A name given to the fecula obtained from the cereal grains, and from the bulbs, stalks, and roots of various plants. The use made of starch in surgery is very limited. Powdered starch is sometimes employed as an external application in erysipelas, and in the cutaneous erubescence of new-born infants; in a liquid jelly it serves as a vehicle for the injection of anodynes into the rectum. As a poultice it is now but very rarely used.

ANABROCHISMUS, *ἀναβροχισμὸς*, (from *ἀνὰ*, "with," *βρόχος*, "a running knot".) An operation of the ancient surgeons for preventing the eye-lashes from turning upon, and irritating the eye, effected by knotting a hair around them. It is mentioned by Hippocrates, Galen, and Celsus. It is now obsolete.

ANAPLASIS, obsolete, *ἀνάπλασις*, Gr. *confirmatio*, Lat. Hippocrates used this term to designate the union or consolidation of a fractured bone.

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[1] The Editor having had the misfortune to be deprived, by illness, of the able assistance of Dr. King, who had originally undertaken to write the article AMPUTATION, was compelled to take up the subject where it was thus interrupted. With the exception of the section entitled *Measures necessary to arrest hæmorrhage after amputation*, the Editor's part of this article embraces from page 142, commencing with the history and description of the Flap Amputation, to the end. He acknowledges with pleasure the great obligations he has been laid under by his friend Mr. Pilcher, who kindly placed at his disposal, for sketching and verifying the wood-cuts which illustrate this article, all the subjects employed during the course of surgical operations delivered by Mr. P. during the present session at the Webb-street School.

ANAPLEROSIS, obsolete, ἀναπλήρωσις, "filling up." That part of surgical therapeutics whose object is to supply, by artificial means, parts that are wanting. (See PROTHESIS.)

ANASARCA, Lat., ἀνάσαρκα, Gr., from ἀνὰ, through, and σὰρξ, the flesh; *Leibwasser, Hautwassersucht*, Ger.; *anasarque*, Fr.; *dropsy of the cellular membrane*, Eng. The term implies a general serous infiltration of the cellular tissue, but more especially the portion of it interposed between the skin and the muscles; when the infiltration is not general, but circumscribed within a particular region, it is known by the name of œdema.

Anasarca, like the other forms of serous effusion, may be either symptomatic or idiopathic; it may be active or passive. Considered without reference to the causes from which it may arise, the infiltrated condition of the cellular tissue, known under the term anasarca, results from the condensation of the animal vapour which is constantly exhaled from all parts of the cellular tissue, whether that condensation is produced by an excess of the secretion itself, or the absence of absorption.

As our notice of this affection is confined to the mere point of view in which it is susceptible of relief or cure from surgical means, it will not be necessary to enter into a full disquisition of its causes, varieties, complications, &c. We shall, therefore, only state in general terms, that it may depend upon excitement or irritation in the cellular tissue itself, or its vessels; on inflammation, or obstruction of the veins, or simply from any mechanical impediment (as for instance, a tumour,) to the free return of the blood; and on various organic alterations in the important organs of the economy, as of the heart, or its large blood-vessels, pericardium, lungs, kidneys, &c.

The causes of anasarca may very naturally be arranged into two classes: in one the symptoms are acute; in the other they are chronic, and symptomatic of some primary affection. In the early stages of life, great activity of function prevails in the cellular tissue, erythematous inflammations are more frequent, and hence the greater frequency of the active forms of anasarca at this period of existence. Youth, vigour, and the sanguineous temperament, therefore, are justly regarded as predisposing, while a too generous alimentation, the suppression of hæmorrhage, either natural or accidental; the sudden stoppage of perspiration; or the impression of cold, especially after eruptive diseases, may be enumerated amongst its occasional causes. It has also been observed to come on suddenly, after violent emotions of the mind, or the disappearance of the symptoms of gout, &c.

The characters of the passive or chronic anasarca are very different: here the phenomena are of the asthenic kind, and are dependent either on morbid affections of the heart, large vessels, lymphatics, of some of the principal viscera, in a word; or on direct debilitation, resulting from insufficient food or clothing, insalubrious habitation, frequent and considerable loss of blood, &c.

The symptoms of this affection, derived as they may be from pathological conditions so essentially different, are serious, or otherwise, in regard to the evanescent excitement or permanent lesion from which they take their origin; and they present a degree of variety dependent on the causes from which they arise.

The sthenic, or acute anasarca that occurs during convalescence from scarlatina, is characterized by the suddenness of its appearance and the rapidity with which it spreads. A great part, sometimes even the whole body, is swollen, although the colour of the skin is scarcely changed, or if it should be, it presents a very slight rosy hue; it is elastic and sensible to the touch; it also seems polished, and hotter than usual. When pressed upon, it does not retain the mark of the fingers, and it sometimes presents, at various points, an erysipelatous blush. These symptoms coincide with others of a constitutional kind. The pulse becomes hard and frequent; the countenance flushed, the eyes brilliant, and the tongue parched. There is great thirst, but no appetite; and sometimes there is severe headache, sickness, and intolerance of noise or light. The urine is scanty and high-coloured. The patient complains of pains in the loins, or in the articulation; he is listless, yet uneasy. Sometimes the severity of the symptoms is still greater: the abdomen is painful to the touch, there are colicky pains, with diarrhœa; excessive difficulty of breathing, with irregular and quickened pulse, and extreme restlessness.

The inflammatory, or active anasarca often occurs, however, without such well-marked symptoms of general reaction. Its progress may be extremely slow. The swelling begins in the feet, and ascends the legs, thighs, scrotum, &c. The colour of the skin remains unchanged, and the augmentation of heat or sensibility is scarcely perceptible. The excitement of the cellular tissue, though obscure, is still the cause of the phenomenon. The infiltration is not of the passive kind.

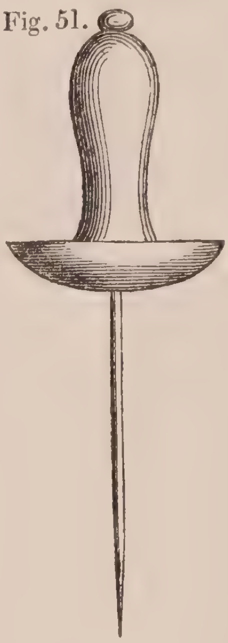
When the anasarca is of the asthenic kind, or symptomatic of some serious lesion, the character and march of the symptoms are different. Before any appearance of infiltration is shown elsewhere, the face is puffed up, and paler than usual, or the ankles are swollen, and present a doughy feel to the touch. The intumescence from this point proceeds at first very slowly. The skin feels cold, and its temperature is in reality reduced; its colour is a dull white or yellow, becoming more and more glossy as the distension increases; its elasticity or resistance diminishes, and it retains, for a considerable time, the pits or seams made upon it by the pressure of the fingers or the clothes. The quantity of the effused fluid becoming more and more considerable, it becomes obedient to the laws of gravitation, and accumulates in those parts which are most depending; but as these become overcharged, it ascends and distends the higher regions.

At first the accumulation seems greatest in the evening, particularly if the patient has been much in the erect position during the day; but after the repose of the night, it seems to disperse so that scarcely a trace of it is to be observed next morning. The quantity increases progressively, until the infiltration is found to be general in the legs, thighs, scrotum, hips, loins, abdomen, chest, neck, face, eyes,—in a word, over all the surface of the body, with the exception of the palms of the hands and soles of the feet. Nor is the effusion confined to the cutaneous cellular tissue; it penetrates also into the intermuscular layers, and along the tracks of the great vessels. The muscular contractility is enfeebled under the great weight of the accumulation, and the patient moves with difficulty; the surface is cold, and its sensibility is often blunted to such a degree that the skin may be cut, or even burned, without the patient's being in the least aware of it. There is great thirst, and the urine is highly coloured, scanty, and sedimentous. When the distension of the skin becomes extreme, it is separated by a considerable distance from the sources by which it is nourished; the capillaries are attenuated, and convey but little blood; and on this account there is a great tendency in the skin to inflame and slough, at various points, and from very trifling lesions.

The pathological condition of the cellular tissue varies according to the cause in which the infiltration has originated, or the length of time the effused fluid has remained, as it were, stagnant in its areoles. When the cause is of the active or sthenic kind, and limited to the cellular element itself, this tissue will be found reddened, injected, and indurated at some points. When, on the other hand, the anasarca is a mere symptom of serious organic lesions, the cellular tissue is a mere recipient; it is inundated with fluid, at first without any sensible alteration of its structure. When this state of things continues, it suffers from maceration, it becomes discoloured, as do also the muscles; their powers of resistance are impaired, and they are torn with the greatest facility. It will be often in the power of the surgeon to prevent this complication by well-timed interference; but in general, the root itself of the evil is much more serious, and is only susceptible of palliation.

Treatment.—The remedies to be had recourse to differ according to the causes and conditions in which the affection has had its origin. When it depends on simple excitement of, and is confined to, the cellular tissue, the antiphlogistic treatment is indicated. Local will be better than general bleeding, except in cases where the disease has been produced by plethora; leeches in sufficient number may be applied to the margin of the anus, or the vulva, when it can be traced to suppression of habitual evacuations by hæmorrhoids, or the catamenia. Some surgeons prefer general bleeding in small quantities, and frequently repeated; and it is certain that the anasarcous swelling is often dissipated very rapidly under this plan of treatment. Saline and diaphoretic medicines are exhibited internally, with nitrated diluents; and punctures may be made, without fear of bad consequences, when the effusion is considerable, in order to give issue to the fluid, and diminish the tension of the skin. The point of a lancet is used for this purpose. An acupuncture needle will be found to answer better. Sir B. Brodie uses a particular kind of needle for evacuating the serum. See fig. 51.

Fig. 51.



The passive form of anasarca, whether it arise from morbid alterations of important organs, or from general debility, unaccompanied by such alterations, is in every point of view a more serious malady. Of course, the chances are more favourable for the patient, when the affection is nothing more than the indication of a general atonic condition. Here we must do the very reverse of what is recommended in the active form of the disease; we must encourage, instead of repressing the movement of reaction. The patient's recovery will reward our perseverance in the employment of proper hygienic and therapeutic means. But when the disease is merely the symptom of some serious lesion of the viscera, or of the great blood-vessels, cure is but too often beyond the reach of art. It is true, the surgeon will succeed in dispersing an anasarcous effusion, dependent on the existence of a tumour, or the development of an aneurismal sac, by extirpating the one, or placing a ligature on the other; but these are inapplicable and insufficient in a vast number of other lesions of the vessels and viscera, and in which the surgeon can do no more than palliate the distress which may arise from the excessive distension which the anasarcous effusion produces.

The punctures recommended to relieve the over-distended skin in the anasarca from cellular inflammation, though capable of effecting the same object, viz. the evacuation of a considerable quantity of the fluid, is by no means so secure against bad consequences, and should be employed with great reserve. In some cases of a very urgent nature it will be proper to have recourse to them. It will be better to relieve the skin from the excessive distension, than to allow it to crack extensively, or to become stripped over the parts on which the patient lies. When the patient's strength is much reduced, the skin is considerably distended, and the distress of breathing is very great; under such circumstances, punctures ought to be made to give issue to the fluid, without regard to the local inflammation and sloughing which may arise in consequence.

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(*Wm. B. Costello.*)

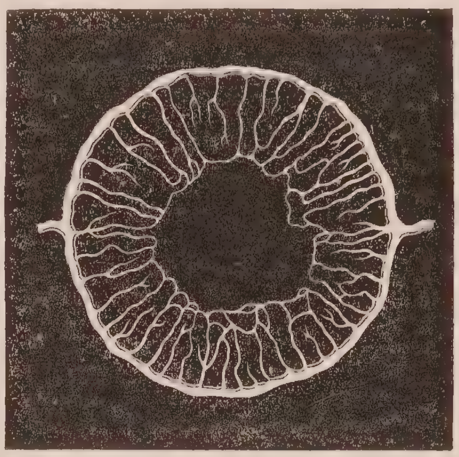
ANASTOMOSIS, (from *ἀνὰ*, through, and *στόμα*, a mouth,) *ἀναστόμωσις*, Gr.; *Verbindung*, Ger.; *anastomose, abouchement*, Fr.; *inosculation*, Eng. Anastomosis, in an anatomical sense, means the communication that obtains between different parts of any system of vessels, nerves, &c., and is found in each of the ramifying systems,—in the arteries, in the veins, in the lymphatics, and in the nerves.

The anastomoses of the *arterial system* which are to be here considered, serve three distinct purposes; they prevent a defective supply of blood; they diminish the velocity in the current of the blood; and they diminish the weight of the column of blood.

To fulfil these different offices, there are different modes by which arteries anastomose. Two trunks of equal diameter may unite to form a single trunk, as, for instance, the two vertebrals, to form the basilar artery; or two trunks may communicate at a particular part by a transverse branch, such as the two anterior cerebral arteries, by the arteria transversalis: or two trunks may join and form an arch, as in the instances of the mesenteric arteries, and coronary arteries of the heart; in those of the stomach, lips, eyelids, and iris; and in the palmar arch.

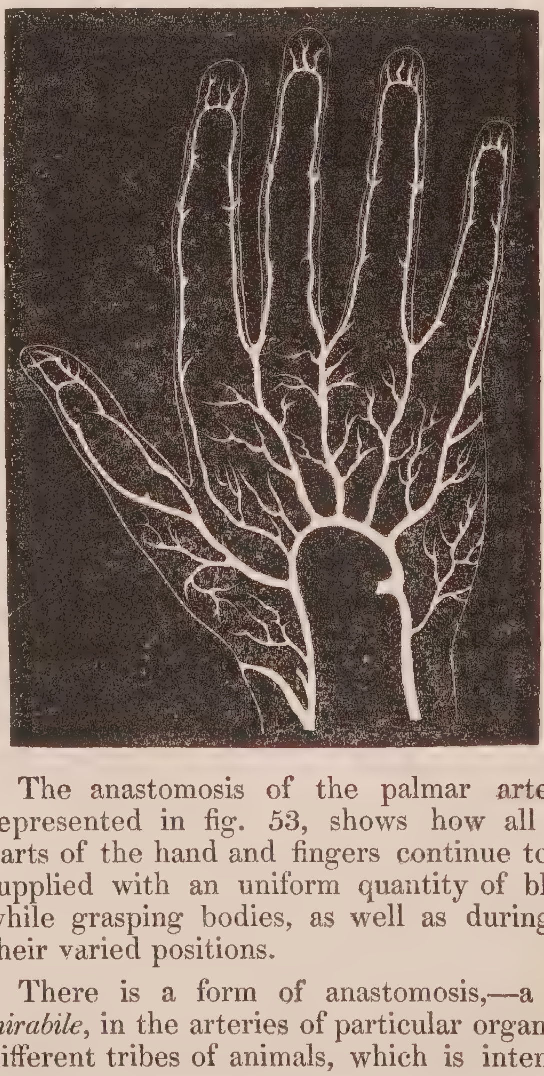
In consequence of these and other inosculations, the due supply of blood to different organs can never be interrupted, though its flow in particular vessels may be obstructed by a variety of causes, particularly by alterations of posture, and by muscular contractions; and hence it is justly remarked, that the arterial system ought not to be compared to a tree, the branches of which are isolated; but to a tree, all the branches of which communicate with one another.

Fig. 52.



The anastomoses of the arteries of the iris, represented in fig. 52, show how that organ is supplied with a constant stream of blood during its unceasing movements. The vessel which is seen passing around the circumference of the iris receives its blood from two channels, so that the circulation can never be interrupted. From this trunk the different branches come off at right angles to supply the iris, pass forwards to the pupillar opening, where they inosculate with each other, forming a sort of festoon, in such manner that the circulation of the blood shall go on uninterruptedly, whether the pupil be in a state of contraction or dilatation.

Fig. 53.



The anastomosis of the palmar arteries represented in fig. 53, shows how all the parts of the hand and fingers continue to be supplied with an uniform quantity of blood while grasping bodies, as well as during all their varied positions.

There is a form of anastomosis,—a *rete mirabile*, in the arteries of particular organs in different tribes of animals, which is intended in some cases to secure an equal supply of blood, in others to prevent an undue supply to the organ, when from the particular habits of the animal, the circulation of the blood is liable to interruption. The *rete mirabile* of Galen, which is met with in Graminivorous Animals, affords a beautiful example of a provision in the mode of the distribution of arteries in the head to prevent any increase in the weight of the column of blood, when the animal is grazing, an effect which would be necessarily produced, did not the internal carotid arteries in that tribe of animals divide, become tortuous, again unite, and in that manner ward off all undue pressure from the increase of the weight of the column of blood which, were these vessels rectilineal, would be caused on the brain, when the head is inclined downwards. In Aquatic Birds, which are in the habit of diving in search of their food, the *rete mirabile* of Hovius affords another example of an artery subdividing and then reuniting for a similar purpose as the *rete mirabile* in the graminivorous animals. As a perfect state of the organs of vision must be more especially requisite in diving birds, when their body is placed perpendicular in gathering their food under water, the subdivision and reunion of the ophthalmic artery or the *rete mirabile* must prevent any injurious effects which would otherwise be caused by the increased weight of the column of blood in the eye, were the ophthalmic artery rectilineal.

Retia mirabilia are also employed in the Cetaceous Fishes to prevent an undue accumulation of arterial blood in the large vessels, and central organ of the circulation, when these animals are deep under water. John Hunter, in his account of the anatomy of the whale, describes a most extraordinary extent of *rete* particularly in the intercostal arteries of these animals; and the same beautiful structure may be seen in the porpoise. When the bodies of the *cetaceæ* are subjected to the enormous pressure to which they are constantly exposed from the immense depth of the waters in which they dwell, the circulation of the blood in the exterior of the body must be interrupted, and hence the blood will be driven into and congested within the thoracic cavity. To prevent any over-distension of the vital organs contained within the chest, the *rete mirabile* formed by the intercostal vessels, acting like a reservoir, will receive the surplus blood, and detain it until the animal rises from the deep, and approaches towards the surface of the water, which, by taking off the pressure of the superincumbent medium allows the circulation of the exterior part of the body to be renewed.

While these forms of anastomosis are had recourse to, in the examples which I have given, in order to prevent an undue quantity of blood being sent to particular organs, I have also mentioned that a similar form of structure is found to be employed for the purpose of securing a proper quantity of blood to a part which, from the habits of some animals, would be otherwise occasionally deprived of its requisite quantity of the sanguineous fluid. The most remarkable illustration of this provision is met with in the limbs of the Sloth, the arteries both of the legs and arms of these animals being formed into a *rete*,—to which, however, Sir Anthony Carlisle, who first described this structure, seems to me to have given a very erroneous and unphilosophical explanation, attributing to this mode of distribution in the arteries, the remarkably slow movements of this tribe of animals. The singular and no less curious part of the natural history of the sloth, is not, however, its extremely sluggish motions, which Sir A. Carlisle conceived could be explained from the peculiarity in the distribution of the brachial and femoral arteries, but the great muscularity which it possesses in grasping, or of suspending its own body for a most extraordinary length of time. "We are told of a sloth that, having fastened itself by its feet to a pole, remained in the situation during fifteen days, and without sustenance! The strength in the legs and feet is so great, that having seized anything, it is almost impossible to oblige this animal to quit its hold. The same sloth grasped a dog that had been let loose upon it, and held it until it perished with hunger[1]!"

The multiplied subdivisions of the brachial and femoral arteries of the sloth, and the subsequent reunion of these vessels into one trunk, must, therefore, be considered as a peculiarity of structure connected with the extraordinary power which these animals possess of clinging to branches of trees for a very prolonged time, and which they are impelled to do, in order to gather their food. Did the artery in the limb consist of one trunk, and was it in the usual situation, it is evident that the circulation would be disturbed, if not altogether interrupted, when the animal grasped with its limbs for any lengthened period; but all such compression is completely averted by the subdivisions of the brachial artery being so numerous at the part of the limb where the pressure is made, that whenever any of the vessels are compressed, and the circulation through them impeded, the blood finds a ready channel in the other branches of the trunk. There is even a further provision to ward off the effects of pressure on the brachial arteries of this animal, and which is so well known in the *feline* tribe,—the artery passing through a foramen on the inner condyle of the humerus; which may, indeed, be considered as an additional proof of the office which is required of the arterial plexus of the artery in the limbs.

The anastomosis of arteries have considerable influence in modifying the *velocity* of the current of the blood in the inosculating branches. This must take place in a remarkable manner in the basilar artery, where the two opposite currents in the vertebral and carotids meet one another; and also in the coronary arteries of the different organs as well as in the inosculations of the mesenteric vessels, and, indeed, of the innumerable arterial capillaries in every organ, and in every part of the body.

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[1] Bewick's Natural History.

Besides the important offices which anastomosis performs in securing to every part of the system a necessary supply of arterial blood as well as of modifying the velocity of the current of blood in different organs, the inosculations of arteries execute a no less important function, when, either from disease or accident, the flow of blood through an arterial trunk has become interrupted. To such extent, indeed, is this office of the anastomosing vessels sometimes demanded, that not only have large arteries been obstructed while the blood continued to be supplied in sufficient quantity to the parts on which they were ramified, but trunks of the first order in magnitude, and even the aorta itself, have been obliterated, and the circulation has been carried on by the anastomosing vessels.

The mode by which this important office of the anastomosing vessels is performed is a subject of interesting investigation. When the obstruction of an artery is caused by disease, as a diminution of the calibre of the vessel must almost in every case take place very slowly, the enlargement of the inosculating vessels must also progressively correspond; but where a ligature is placed on an artery, or the flow of blood through it, is by any cause suddenly interrupted, the changes in the inosculating branches, or in those vessels which are to supply the part with the blood to which the obstructed artery was distributed, must be immediate. These changes have been observed by examining limbs in which the principal arterial trunk had been obstructed, and the parts examined at different periods after a ligature had been placed on an arterial trunk, more particularly in cases wherever such an operation had been performed for the cure of aneurism. Some changes in the inosculating vessels may also be observed during life, when the inosculating branches are superficial, as the branch of the external carotid; or, still more distinctly, when they are also situated in a transparent part such as the conjunctiva or the cornea.

No sooner is the circulation through an artery obstructed, than an immediate change takes place in the anastomosing vessels. I had an opportunity of observing these changes in the branches of the external carotid artery, after a ligature was placed on the trunk of the common carotid artery of the opposite side, in the instance of a very young and emaciated subject, so that the vessels could be distinctly seen through the thin and delicate skin which covered them. No sooner was the flow of blood through the common trunk of the carotid artery impeded, than the branches of the external carotid of the opposite side of the head, more particularly the temporal and occipital vessels, became manifestly enlarged and tortuous, exactly in the same manner as when an injection is forcibly thrown into the arteries of the dead body, whilst, at the same time their action became very much increased.

It is by no means unfrequent, when a part of the cornea has become dim, or a speck has been formed in consequence of previous inflammation, that one or more vessels conveying red blood pass across the transparent part of the cornea and terminate in the speck. However dubious the benefit from such a practice may generally be, yet the vessels in such cases have frequently been divided, in order to prevent the speck being nourished, and thus to aid the action of local stimulants in promoting the absorption of the opaque matter. When only one red vessel can be discriminated passing into a speck, and if it be not only divided, but a portion of it also removed, and the eye examined, even a few hours afterwards, besides more or less redness, both of the corneal and sclerotic conjunctiva, occasioned by the excitement of the operation, the divided vessel appears regenerated, and a trunk is observed of the same size, and precisely in the same situation, uniting with, or in continuation of that portion of the canal which had been not only divided, but altogether removed.

The changes which have been met with in the dissection of limbs, the arterial trunks of which had been obliterated for the cure of aneurism, satisfactorily explain not only the ultimate changes of the inosculating vessels which are employed to carry on the circulation, but enable us satisfactorily to account for the immediate effects which take place on the inosculating branches, when the circulation through an arterial trunk is suddenly obstructed; they also explain the cause of that singular appearance, the almost immediate regeneration of an artery, observed when a portion of a vessel passing into a speck of the cornea has been removed.

From the dissections of limbs which have been operated upon for aneurism, at a very long period after the operation had been performed, a trunk almost as large as the femoral artery itself has been found so near the site of the original trunk that it must have been mistaken for it, had not the thickened and collapsed cord into which the obstructed vessel was converted been discovered. In a patient, whose limb was amputated many years after the femoral artery had been obliterated, for the cure of a popliteal aneurism, there was a trunk observed on the surface of the stump, similar in size, and apparently situated so precisely in the place of the femoral artery, that the operator was puzzled to account for the appearance, but the circumstance was readily explained by finding, on the examination of the amputated limb, the remains of the original vessel converted into a substance resembling the umbilical cord, whilst the limb was chiefly supplied with blood by a large trunk which ran parallel, and in close contact with the obliterated vessel, (A. Cooper). This interesting fact will, therefore, account for the hitherto inexplicable circumstance which has been mentioned, of the almost immediate appearance of a red vessel on the cornea even after a portion of one has been removed: the new vessel, under such circumstances, not being a reunion of the divided mouths, or a regeneration of the portion of the canal which was cut away, but the enlargement of an adjacent inosculating branch.

It ought to be observed, that however rapidly such a change may take place, when such small vessels as those of the cornea are divided, or a portion of them removed, a much longer period is necessary for one inosculating vessel adjacent to the obliterated trunk to undergo such an increase of its calibre, and attain such a size as to be the chief means of carrying on the circulation. When the circulation is suddenly cut off in the main trunk, all the anastomosing branches bear a part in carrying blood to the organs or parts thus deprived of their supply. The contributions of all are required in the first instance. This service is, however, but temporary. After the lapse of some time, one or more of these vessels becomes permanently enlarged, through which the circulation is continued, while the inordinate function of the others being now no longer necessary, they shrink to their primitive size. We may, therefore, conclude from the phenomena which are observed to take place in the branches of the external carotid artery, when a ligature has been placed upon the common trunk of the carotid at the opposite side of the neck, that there is not only an immediate change in the inosculating vessels, but that they at first all participate, every one being employed to supply to the member its defective quantity of blood, whilst it is only after the lapse of many months that one of the inosculating vessels performs, almost entirely, the office for which numerous branches were at first employed.

(*James Wardrop*).

ANATOMY, MORBID. Morbid anatomy, or pathological anatomy, comprises that division of the science of anatomy which treats of deviations from the normal or healthy state which the bodies of animals in general, and of man in particular, may exhibit as a whole, or in any of their parts or organs, as the result either of original malformation, or of disease or accident.

Although it is obvious that so comprehensive a subject must furnish abundant materials for separate and distinct consideration, yet it may very naturally be supposed that most, if not all these objects are so closely connected with those of the general and special anatomist, as well as with those to be treated of under the heads of surgery and medicine, that a distinct article must involve needless repetition. An author who is engaged with the description of the features and treatment of a medical or surgical disease, must unquestionably find himself compelled to treat of the morbid anatomy of that particular subject. It is not, therefore, the object of the present article to interfere with, or supersede those pathological descriptions, which must be scattered through, and inseparably interwoven with the individual articles in the Cyclopædia of Surgery. The distinct consideration of the subjects presented by pathological anatomy, as a whole, will not only render those scattered descriptions more intelligible, and consequently more easily retained in the memory; but it may be regarded as essential to the setting forth of the analogy or similarity between the derangements of different parts and textures of the body.

It will also show that in the disturbed operations of organic life, which give rise to the almost innumerable irregularities which present themselves to our view, there is, nevertheless, an order and regularity in these very aberrations, and that they lose much of their apparent intricacy when we obtain the clue or key.

The deviations from the healthy or normal condition of the human body, or its parts, although admitting of almost endless varieties, may, notwithstanding, be arranged in two distinct groups,—the one comprising those deviations which consist of perversion in size, proportion, form, number, or situation, interruptions of continuity, and in short, whatever change simply requires the accurate knowledge of the minute special anatomist for its detection. The other group of deviations comprehends whatever changes may be brought about in the intimate tissues or structures of which the various parts of the body are composed. It comprehends a class of phenomena which require for their perception and appreciation a thorough acquaintance with the too much neglected department of general anatomy. Although we have here two essentially distinct modes of deviation, yet we shall necessarily find in practice that these modes are continually blended together in the same cases. The organ which has become so enlarged as to attract attention by its dimensions, and occasion the displacement of other organs, which the descriptive anatomist will minutely detail, will almost invariably be found to present, throughout the whole or a part of its increased bulk, some more or less striking deviation from the healthy arrangement of its particles, which cannot fail to suggest a query as to the nature of the change of composition which has taken place. The general anatomist, to whose department this question would seem to belong, may recognise a structure with which he was acquainted, but which special anatomy will inform him does not naturally belong to the part of the body in which it may have been found, or, at least, to the extent in which it has occurred. Thus, he may find that the mass on which he is called to pronounce an opinion, consists of bony matter, which does not, in the healthy state, exist in the part of the body in which it has been discovered; or it may be a mass of fat, which, though it may present very much the character of healthy adipose substance, is irregular or morbid as furnished by a part in which it ought not to have existed. But the general anatomist will not always recognise a structure with which he is acquainted; and special anatomy may inform him that the substance under examination has been found in the situation of this or that organ which could not be discovered in its healthy state, and consequently there may be reason to believe that the body under examination in some way or other owed its origin to the organ of which it has taken the place. Furnished with this information, the inquirer will proceed to examine the peculiarity of this strange texture; and he may discover, or conceive that he discovers in it, some traces of the natural structure which should have existed in that situation, or, on the other hand, the substance under examination may present so foreign an appearance as to lead to the conclusion that some entirely new growth has taken the place of the original structure. The general anatomist, as well as the special anatomist, will therefore find that he is engaged in an inquiry beyond the limits of his department, though closely bordering upon it. It belongs to morbid anatomy to solve the question, or to pursue the inquiry, if that which is already known be imperfect.

The cases which have been just supposed will serve to illustrate three subdivisions which morbid anatomists have employed, and respecting which there has been great disagreement and controversy. Where the body whose irregular presence has attracted attention is found to consist of bone or fat, or some other structure which the general anatomist recognises as natural to the body, the morbid appearance is said to consist of *the accidental production of a natural or analogous tissue.* When the natural structure no longer exists, although some trace of the structure belonging to the part may still be discoverable, the morbid appearance is said to depend on *the degeneration of the natural structure;* but when the pre-existing natural structure has given way to the encroachments of an entirely new production, it is said that the morbid appearance is the result of the *accidental formation of a new, distinct, or heterologue tissue.* This distinction, which appears plain, simple, and natural, and strictly inherent in the nature of the subject, would probably command universal assent were it not for the difficulty of deciding, in various cases, as to the group under which the morbid structure should be placed. The distinction between the degenerations and adventitious productions of the heterologue kind has produced a schism, in opinion at least, between some of the most acute and able pathologists, and each sect has had its zealous partizans. A minute knowledge of the intimate structure of the diseased part, and of the steps in the process by which it has been produced, can alone settle these disputed points. In the meantime the morbid anatomist, whilst he may adopt or reject the views of one particular sect, should be no less acquainted with those adopted by his brethren who may dissent from it; and it is especially expedient that he should not only have a clear perception of the various forms of diseased texture, and of their distinctive differences, but that, in speaking or writing respecting them, he should adopt terms and expressions sufficiently explicit, that others may not be at a loss respecting the particular form or mode of derangement to which allusion is made. Errors and defects in this respect are by no means unfrequent in writings and discourses concerning the objects of morbid anatomy, and they are the more to be regretted because they not only occasion misunderstanding between the parties immediately concerned, but tend materially to retard the progress of this department of science, by incumbering it with adventitious difficulties This evil does not wholly, or even principally, depend upon the nomenclature of the science, which I shall have to notice hereafter. It is perhaps yet more to be attributed to the want of precise ideas to be conveyed by the terms employed. The increased accuracy and precision which have of late years been adopted by pathological writers, the multiplication of museums rich in pathological preparations, and the increased fidelity of pictorial representations which have been numerously published and widely circulated, will do much to remedy the evil here complained of, but it is only to be wholly removed by the members of the medical profession individually taking up the study of morbid anatomy as a distinct and integral part of medical science.

It is essential to the apprehension of the numerous phenomena presented by morbid anatomy that they should be reduced to a systematic classification. Although in such a classification we must have nature for our guide, the divisions and subdivisions must in some degree be artificial, consequently various systems may be constructed according to the various views of those who may undertake to make them. The following, which is given as a specimen, has been found practically convenient; and as, in the present case, it will serve as a key to some of the observations which will follow, it will illustrate the truth of the observation, that classification is necessary. Deviations from the normal state may consist,

1. In deficiency.
    a. The result of suspended development.
    b. The result of loss sustained, or privation.
2. In excess.
3. In alteration of form.
4. In appearances which may be regarded as the result of ordinary inflammation.
5. In appearances which are the result of scrofula.
6. In appearances which depend on diseases called malignant, or which resemble them in structure, viz.,
    a. The adventitious production of cysts, generally pedunculated, and assuming the form of reflected membranes, erroneously called "Hydatids," and which are often

unaccompanied by constitutional affection or taint.

b. True scirrhus,

c. Fungus hæmatodes or medullaris, medullary sarcoma, fungoid disease, spungoid inflammation, cerebriform cancer, &c.

d. Melanosis, in that particular form which exhibits a structure resembling the preceding, to which the term "melanosis," as descriptive of a specific affection, may, for convenience and precision, be restricted.

7. In Hydatids or other parasitical animals lodged in the particular organ.

8. In the effects of accidental injury.

Deficiency.—This may proceed from two causes: it may be the result of original defect, or the part having existed in its original state may have suffered loss. From either of these causes the deficiency may be absolute and total, in which case we have only to consider the causes which have led to it; but before admitting total deficiency, it is essential carefully to ascertain that the part in question is not in existence, either as a rudiment, or debris.

If the part continue to exist, it may be the subject of deficiency either by a general diminution of size, or by the total or partial absence of some of its subordinate parts.

Excess.—Excess admits of varieties in some respects analogous to those which have been noticed in the case of deficiency. A part may be preternaturally large from original formation, as we sometimes see to be the case with a child's head, in other respects perfectly well formed, or the enlargement may be secondary, as when the enlarged head is the result of a morbid collection of fluid in the ventricles of the brain. Sometimes the excess of one part is the result of deficiency in another, as, for example, one kidney being suppressed or destroyed, the other acquires increase of volume, as well as of function. Sometimes increase of size, or hypertrophy as it is called, is simply the result of increase of function, as, for example, when the heart becomes enlarged in consequence of various causes rendering the circulation of the blood more difficult. In some organs great variations in size may take place independently of disease, and in obedience to the laws of nature. The most striking examples of this kind are seen, in the inferior animals, as, for example, in the vernal increase of the size of the frog's thumb, and in the prodigious enlargement of the testes of some animals about the same season. Excess may consist in the increase of the number of organs, as, for example, when, instead of one spleen, we find four, or even five. Instances are by no means rare of the hand having six instead of five fingers. Examples of excess like the last-mentioned take place in conformity with the law pointed out by Bichat, viz., that the component parts of limbs increase in number as they become distant from the trunk or centre; thus the upper arm has one bone, the humerus; the fore arm two, the radius and ulna; the carpal rows have each four, and the metacarpal five, which, in the abnormal cases above-mentioned, are increased to six. Excess in number sometimes takes place in the parts of organs rather than in additional entire organs, as, for example, when the lungs or the liver are divided into an unusual number of lobes. Excess with respect to the number of organs or parts of organs, in the human subject at least, may be always said to be congenital; but whilst in some instances this anomaly is the result of original mal-conformation, as in the case of six instead of five fingers, in others it is the consequence of the persistence of parts which, in the ordinary progress of growth, are suppressed in their development. Of this description are supernumerary ribs and the os coccygis prolonged into a tail, or parts originally formed in two portions destined to be ultimately united may fail to become so, as in cases of hare-lip and double uvula. Although in the human subject excess in number appears to be always congenital, in some of the inferior animals it may be subsequently acquired; thus certain reptiles which have the power of re-producing a tail when the original has been amputated, have been known, after injury to that organ, to produce a second, although the first has continued to be attached and nourished.

Excess in the number of organs, or parts of organs, has been ascribed to a kind of compensation, as when a child has been born with four fingers or four toes to the hand or foot, the same mother has given birth to another having six fingers or six toes.

Deviation in respect of form.—Anomaly in this respect may be of such infinite variety, that it would be in vain to attempt to describe it; but its characters are so obvious that description is unnecessary. It may, however, be brought about in various ways: it may depend on original formation, as, for example, when the nose, instead of possessing its usual shape, assumes the form of a trunk,—a kind of monstrosity not very rare in the human subject, and rather frequent in some of the inferior animals, and generally, if not invariably, concurring with the union or near approach of the eyes on the median line.

Perversion of form may be likewise acquired under the modifying operation of some neighbouring influence, as, for example, when the convex surface of the liver is indented by some anomaly in the form of the diaphragm, or when the form of the kidney is distorted by unusual pressure, occasioned by curvature of the spine. Some of the most striking perversions of form of this description are produced designedly by artificial means, employed through ignorance or culpable folly. The practice of moulding the form of the infant's head, so as to produce a remarkable flatness of the forehead, has, from time immemorial, prevailed over a large district of the new world, insular and continental. The practice of distorting and crippling the ladies' feet in China by means of early-applied and forcible compression, is another well-known instance of distortion of this kind. We may find instances equally atrocious without looking beyond the civilized countries of Europe. Even in some of these the form of the head is often injuriously, as well as disfiguringly distorted by the application of bandages. An excellent pamphlet on this subject has recently been published by Dr. Foville, who has not merely pointed out the perversions of form generally produced, but has also shown, from careful statistical inquiry, the serious influence exerted on the intellectual faculties in strongly disposing to epilepsy and insanity. There is, perhaps, no distortion of this kind which is more frequent, or more injurious and culpable, than that which is practised on the chests of females by tight lacing, employed with a view of producing a slender waist. The lower ribs, which should form the base of a cone, are so coerced as almost to form its apex, and instead of admitting of the most extensive motion they are rendered completely fixed, to the most serious interruption of respiration; at the same time the diaphragm, and likewise the abdominal viscera, are deranged both in form and function.

There are some morbid perversions of form, which, although existing from birth, may be ascribed to the influence of a modifying force applied to the distorted organ, rather than to any inherent vice in the *nisus formativus* of the part. Club feet, and other distortions of the limbs, may be regarded as of this class, and referred to causes which have acted upon the fœtus *in utero*. The umbilical cord has been supposed by Geoffroy St. Hilaire to influence some of these distortions by preternatural shortness, or by malposition.

Distortion of form sometimes takes place in consequence of the concurrence of a diminution in the resisting power of a part in conjunction with the application of a modifying force applied to it. Although in this form of distortion a change of tissue is concerned, it is necessary to notice it under this head, since the distortion often continues after the morbid condition in the texture of the part has ceased. The heads of children sometimes have such an unusual degree of pliancy that they lose their symmetry by their own weight, and if allowed to remain constantly or generally in one position, the loss of symmetry becomes permanent. I have observed the progress of this loss of symmetry in children labouring under acute affections of the head, in whom the natural pliability of this part appeared to be considerably increased, whilst the cause of distortion occasioned by the child lying for the sake of ease in one position was probably increased by the weight of accumulated fluid in the ventricles of the brain. I have known this distortion almost entirely removed, although it had become very considerable, on the child's recovering health and strength, which allowed the position of the head to be variously changed; but we often meet with individuals, in whom a want of symmetry of this description has become striking and permanent. A distortion of this kind is very frequent in heads brought from the South Sea Islands, and I have been informed by W. S. Stuchbury, formerly naturalist to the South Pacific Pearl Company, that this want of symmetry was obviously occasioned by the mode of nursing infants, which allows the head to rest on the lateral and posterior part.

There is another form of distortion of the head which is not very common, and does not appear to have been specially noticed, which would seem also referable to a transient morbid state. The upper and lateral part of the cranium on each side becomes flattened and depressed, so as to give the upper part of the head the form of a ridge, taking the direction of the sagittal suture. Without the assistance of any history to explain this peculiarity of form, it seems not unreasonable to regard it as the result of the absorption of a preternatural quantity of fluid in the ventricles, taking place after the process of ossification had closed the fontenelles; so that the necessary diminution of the capacity of the skull could not be brought about at their expense.

Some very serious and disfiguring distortions of form belong to the section now under consideration. Perhaps the most remarkable and important of these, is the distortion of the pelvis, occasioned by the combined influence of the weight of the body, and the resistance of the heads of the thigh bones, when the individual is standing. When rickets, or other morbid conditions, have greatly reduced the resisting power of the bones, the distortion thus produced is so considerable and irremediable, as to render parturition impossible without death to the mother or child, or to both. Great distortion of the leg bones is frequently brought about by a similar concurrence of circumstances, and many children have grown up in a state of unsightly deformity, in consequence of having been allowed, or even compelled, to stand or walk whilst their limbs were in a state of morbid weakness: the evil is in many cases rather aggravated than remedied by the application of irons with the view to counteract it.

The fourth head comprises those deviations from the normal state which are the result of the *inflammatory process*. The most numerous and most important pathological conditions belong to this section. It will not be necessary on the present occasion to enter into the consideration of the knotty subject of the intimate nature of that condition which we designate by the term inflammation, we may rather refer to the article under that head, and in the mean time, we may take for granted, that the term is sufficiently understood to mark the distinction to be made between the subjects falling under this head, and those which belong to other sections.

In observing and describing the appearances resulting from inflammation, it is necessary to distinguish those which depend on its recent, from those which belong to its advanced state, and those which it leaves behind it, when it ceases to be in operation. It is also necessary to distinguish the acute from the chronic form. The phenomena of ulceration and suppuration manifestly fall to be considered under this head; but they necessarily require subdivision, independently of that into the acute and chronic before alluded to, seeing that there are inflammations of a specific character which greatly modify the appearance of the affected part, as well as the general and local symptoms which attend them. Thus, we have the specific ulceration of venereal origin; closely allied to which, are those produced by sibbins and yaws. The virus discharged from a glandered or farcyed horse produces an untractable, and often fatal ulceration, which also appears to be of a specific character. The ulceration with which sweeps are liable to be affected from the influence of soot seems to be produced by an inflammation of a specific kind; and though designated by the term, Chimney-sweeper's Cancer, appears to be totally distinct from those affections, which can with propriety be included under the term cancer, even in its most comprehensive sense, since these affections, though regarded by some as modifications of the inflammatory process, are unquestionably distinct from it, and form a peculiar class by themselves. Notwithstanding the preceding remarks, it will be proper to observe, that parts to which some of the forms of cancer have given rise as an adventitious structure may, like parts natural to the body, become the subject of decided inflammation. This circumstance may serve to account for the error of those who have fallen into the confusion above alluded to. Amongst the phenomena dependent on inflammation, it must be noticed, that there are not merely those which consist in alteration of the tissues affected by the morbid process: there are others dependent on the formation of a new material, which is to be regarded as the product of parts whilst under inflammation. The differences in the character of this product may be regarded as important indications of differences in the process itself. Thus, sometimes, the inflamed part pours out a fluid which has the power of coagulating, and having done so, of receiving vessels, which are *elongations*, or *prolongations* of the vessels of the inflamed part. The product of inflammation thus becomes a new structure, which is either placed upon the old, and is consequently recognisable as an added part; as, for example, when layers and bridles of adhesion unite the opposed surfaces of the pleura, or the new structure may be intimately blended with the original tissue, adding to its bulk and density; as, for example, when the substance of a serous membrane itself appears to be thickened; or more remarkably, when a portion of cellular membrane having been infiltrated with this kind of product of inflammation is not only increased in bulk, but may be so altered in its structure as to lose the character of cellular membrane, and rather resemble cartilage or fibro-cartilage. When this change has been effected, it is important not to confound it with the result of a very different process, and regard it as of the nature of scirrhus. At other times the product of inflammation, whether in the state of fluid or solid, is altogether incapable of becoming organized, and if retained by the system, must be regarded as acting the part of a foreign body. Differences in the product of inflammation of the kind just described, have been noticed as marking the adhesive and the suppurative stages of inflammation, or as denoting differences in the mode of inflammation dependent on the tissue affected. Thus, the first, or the adhesive form has been said to belong to the serous membranes; and the second or the suppurative, to the mucous. Although there can be no doubt that the one form may succeed to the other, and that different tissues are more liable to be affected by the one than by the other, it does not appear to be strictly correct to regard them either as different stages of one process, or, as consisting of modifications simply dependent on the variety of tissue affected. The character of each of these forms may be exhibited by nearly, if not quite, every living tissue, and may also exist independently of the other from the commencement of the attack. Whatever view may be taken of the relation which these two forms of inflammation bear to each other, it is essential to distinguish them in morbid appearances, and it would doubtless be of incalculable importance with respect to the mode of treatment, could they be satisfactorily distinguished during the progress of the malady. There are many intermediate varieties between these two forms of inflammation, and some curious and important phenomena appear to depend on their combined operation.

The term *erysipelatous*, which is sometimes employed to designate a particular form of inflammation, appears to require some comment. A difficulty appears to have arisen in consequence of the laxity and want of uniformity with which it has been employed. Some seem to consider it essential that a certain degree of vesication should be present; in which case, it can only affect parts furnished with an epiderm; others, again, employ the term as expressive of a form of inflammation, which has a considerable disposition to spread, and does so without exhibiting any distinct line of demarcation, or meeting with any obstacle to its progress. With some, the production of pus is held to be incompatible with erysipelas, whilst others admit a phlegmonous form of erysipelas.

Sphacelus and gangrene may also be considered under the head of inflammation, since, though not invariably the result of that process, they very often are so, and are always accompanied with a change somewhat allied to it.

Under the fifth head are arranged those deviations from the healthy state which depend upon scrofula or struma. It must be allowed that there is very sufficient ground for questioning the propriety of separating the phenomena of scrofula from those of inflammation, since it is most probable that it consists in a variety of inflammation rather than any distinct process; there are, however, so many peculiar conditions attendant both on the local and general appearances, and they constitute so important as well as so marked a class of derangements, that there is a manifest practical advantage, although, possibly, some irregularity in making this division, which, however, is sanctioned by the view which has been entertained by some pathologists respecting the nature of scrofula. The most striking feature of scrofula is the production of a new material, which has been called scrofulous or tuberculous matter, in one or more parts of the system. It is met with under several varieties which appear to depend on changes which it may undergo from its first formation, till its expulsion from the body, or till it acquires a form in which it may remain quietly lodged in the system; nevertheless, some of the differences which it presents may depend on varieties of the strumous state, or on the peculiarities of the parts in which it happens to be situated.

By some pathologists, at the head of whom may be placed Laennec, who has carefully studied the phenomena connected with tuberculous matter situated in different parts of the body besides the lungs, it is considered that this material commences in a semitransparent and gelatiniform state,—that it subsequently becomes opaque; for a time acquires an increased density, but ultimately undergoes a process of decay attended with softening commencing at the central part of the mass, and thence extending to every part, and preparing the way for its expulsion through an ulcerated opening formed for its exit. Andral, another highly respectable authority, denies the conversion from the semitransparent to the opaque state, and considers that tuberculous matter is formed at once opaque and friable, that there is often no semitransparent deposit, and that when there is, it is not to be regarded as the early state of the tuberculous matter, but rather the nidus in which it is deposited. Laennec and some of his disciples have considered tuberculous matter as an accidental tissue. Others, amongst whom Andral may again be mentioned, regard it as a secretion, and in pathological classification closely allied to pus. This latter opinion appears to be more correct; nevertheless, it must be observed that although tuberculous matter is incapable of organization, or of maintaining life in connexion with surrounding parts, it does, however, undergo changes in which vitality is concerned; and if the transparent gelatiniform state be admitted, which is by no means disproved, it would seem that in its early stage it approaches to the character of that plastic product of inflammation which is susceptible of organization, whilst in its advanced stage it is as inorganizable and excrementitious as pus itself. The possibility of tuberculous matter being susceptible of absorption, or not, has, like some of the points already alluded to, been the subject of difference of opinion and controversy.

The question is one of practical importance, since upon it will depend the propriety of pushing the use of some active agents with the hope of producing absorption, which would not only be useless but objectionable were the idea of absorption wholly inadmissible. The fact is probably this; that the absorption or non-absorption of a scrofulous enlargement, must in a great measure depend upon the stage at which the swelling may be, when the attempt is made. Although the existence of a peculiar material designated by the terms scrofulous, tuberculous, or caseous matter, is the most striking and most decisive characteristic of scrofulous derangement, yet the general characteristics of a strumous constitution, and even some local derangement may take place prior to the existence of any of this material. The intimate structure of parts seems to undergo a change by which the proportion of their elements is affected. Thus, the bones in young subjects contain less than the ordinary proportion of earthy matter, and are consequently liable to distortion from the child's own weight, or the application of some external force. The absorbent glands are often paler, and seem to contain a large proportion of fluid parts. The brain, and perhaps some other soft parts seem at times to receive a more than usual quantity of blood, and appear preternaturally vascular. With this change of texture, there is often an alteration in size as well as figure, the bones, especially towards their extremities, become enlarged. This is often strikingly the case with the absorbent glands, and hypertrophy of the brain itself is not very uncommon in children. The state of the constitution on which these changes depend has not inaptly been styled strumous cachexia, and is well deserving of the most serious attention on the part of both medical and surgical practitioners. Some excellent observations have been made respecting it by Dr. Todd, and they have been carried out to a further extent in the very valuable work of Dr. Clarke on consumptive diseases. For the various appearances and stages of tuberculous matter, in different organs, and for an interesting inquiry respecting the comparative frequency with which they are affected, the works of Laennec, Louis, Andral, and Lombard, and that by Dr. Clarke already mentioned may be very advantageously consulted. For the external or more strictly surgical peculiarities of scrofula, treatises on glandular tumours, affections of the joints, and on lumbar and psoas abscess, by English and foreign surgeons, may be referred to: amongst these the following may be enumerated:—Pott, Brodie, Lloyd, Goodlad, Syme, Blackburn, (in the Guy's Hospital Reports,) Chopart and Carmichael.

The next section comprises a very distinct and very interesting class of morbid structures, which essentially consist in a new growth superadded to the parts in or upon that with which they are connected. It comprises the following principal divisions:—non-malignant compound serous cysts; cancer; the varieties of fungoid disease, viz., fungus medullaris, fungus hæmatodes, gum cancer, and melanosis.

The characteristics of this section being dependant rather on structural arrangement than on the chemical or physical properties of the substance upon which the peculiar form is impressed, we shall find that some of these growths are analogous to those natural to the body, whilst others are heterologue, or differing from them. The variety placed at the head of this class, and which, from the clearness with which its parts are distinguished, may be regarded as typical of the family, are of the first or analogous kind, whilst those which succeed comprehend all the most important heterologue structures which the bodies of animals are liable to produce. In the infancy of the science of morbid anatomy, the terms employed to designate most of the affections comprised in this group were extremely vague and very irregularly employed. every enlargement, in a part, might be called a tumour, and everything hard, scirrhus. It was an improvement in technical precision which recognised the family of malignant diseases, and distinguished them by the common appellation of cancer. Further inquiries showed that further subdivisions were necessary, and it happened, somewhat remarkably, that the investigation of cancer was carried on almost simultaneously by different individuals both in this country and on the continent. Bayle, Laennec, and Cayol, in France, distinguished encephaloid and melanotic tumours from the group of ordinary cancers; Laennec also pointed out other forms of disease of this class, namely, gum cancer and cirrhosis. He likewise studied the anatomical character and progress of these affections, and noticed their generally rounded figure; the cysts by which they are so generally invested; their original softness or fluidity; their subsequent consolidation; and their ultimate softening commencing at their centres. He, moreover, insisted on their existence as new and adventitious structures in opposition to the opinion of some contemporary teachers, who held that they ought to be regarded as mere degenerations. In this country, the same subject was investigated by Abernethy, Langstaff, Wardrop, and some others. Medullary carcinoma, spongoid inflammation, fungus hæmatodes, and fungoid disease, are the names employed by these authors to designate the most important of these affections, cerebriform, or medullary cancer. Since the attention of the profession has been turned to this subject by the inquirers just enumerated, several other authors have treated of these derangements either generally, or as affecting particular parts. Amongst the works thus produced, I may be allowed to refer to that, little as it is, which I have had the satisfaction of contributing to our knowledge of the anatomical character of this class of diseases.

From the careful examination of a great number of these adventitious growths, from the most distinct to the most obscure, I have arrived at absolute conviction that they all depend on one essential mode of formation, which allies them to the compound serous and mucous cysts, which possess the greatest distinctness, and are, perhaps, of the most frequent occurrence in the ovaries and their neighbourhood.

The numerous varieties of form and texture which we meet with in this extensive group of morbid productions, may, when this key is obtained, be satisfactorily referred to certain modifications of the cystic character, to different proportions of the fluid and solid parts, and to the nature of the material to which this particular structure or arrangement is given.

This remarkable form of adventitious productions is found in other classes of mammalia besides man, and has also been met with in birds.

So general and marked a type points to the operation of some common laws dependant on the properties of the material so organized[1].

The morbid appearances dependant on the existence of hydatids and other parasitical animals, require, for more reasons than one, to be placed in a distinct and separate class. In the first place, they are attended by phenomena peculiar to themselves; for whilst they exist as foreign substances in the texture of the body, they differ from every other foreign body so lodged, in possessing a proper life of their own, in virtue of which they increase in size, and sometimes acquire enormous dimensions, and consequently occasion progressive displacement and modification of the part in which they are lodged. The circumstance of their possessing this independent life, appears to be the cause of their producing little or no irritation of the parts in which they are lodged, during the early period of their existence: nevertheless, their death at a subsequent period occasions their undergoing those changes which may render them the cause of the most serious and fatal disturbance. Another circumstance which renders it important to give separate and distinct attention to this class of morbid productions, is the possibility of confounding them with phenomena belonging to the two last mentioned classes, a palpable error into which some noted pathologists have actually fallen.

[1] See Lectures on the morbid anatomy of the serous and mucous membranes, vol. i.

The last division comprises a very great number and variety of morbid appearances, in which many of the characters already named will be present. It embraces all those derangements which are the result of accidental injuries.

The classification of pathological alterations, of which an outline has just been sketched, may be applied to different parts in various methods.

That which is founded on the divisions of general anatomy, is the most convenient for the elucidation of the subject in a course of lectures.

Other classifications may be more advantageously employed, both for the arrangement of the preparations in a museum, and in treating of pathology in connexion with symptoms; since for both of these purposes it is desirable to bring together *the derangement of a particular part, or of the apparatus of a particular function.* I believe that the classification exhibited in the second table of the catalogue of the Museum of Guy's Hospital will be found as convenient as any which has been proposed for these objects.

Pathological anatomy, like most other subjects which have of late years become the matter of special attention, has acquired a nomenclature of its own. Although a good and expressive nomenclature in any science is unquestionably a great advantage as an aid to classification, and in affording great facilities to description by saving endless repetitions, and long periphrases; there is also no doubt that nomenclature may be abused to the incumbrance and obscurity of the science to which it is applied.

Morbid anatomy is not free from this evil, although it exists to a less extent than is the case in some other departments of science, which relate to more numerous and complicated objects.

Although the terms employed by pathological anatomists are already sufficiently numerous to render a good glossary an important desideratum, it is less in the number of the terms newly invented than in the mode of their application, that the principal cause of obscurity exists. I shall not attempt to pursue this subject at present, since it might be extended to many pages, but I shall adduce a few examples by way of illustration.

Many of the terms employed in pathological anatomy, show by their etymology, more or less of the meaning which they are designed to convey, as may be seen in the words *hyperœmia, anœmia, hypercrinia, and acrinia,* employed by Andral; and in the terms *epiphlogose, metaphlogose, hyperphlogose, osteosclerose, osteophile, gonocace, spondylocace, phlebectasie,* and many others made use of by Lobstein. In some other words the meaning is still less concealed, but being designed to convey the idea of a resemblance which can never be exact, and literally susceptible of acceptation, the application must be vague and indeterminate. Of this description are the terms *pancreatic, lardaceous, miltlike,* and other terms applied to tumours.

The difficulty, in many instances, does not depend on the obscurity of the meaning, but rather on the vagueness and laxity of the application, the same term being either applied to different objects at different times, or made to embrace a variety of objects essentially distinct. The word *hydatid* is an illustration of the statement which I have just made. From its etymology, it may be said to be applicable to any cyst containing a watery fluid, and as such, we find it made use of in speaking of those watery vesicular bodies which are occasionally found in the structures of the body, but not having any direct connexion with the parts in which they are lodged, give evidence of a distinct life of their own. Such are the *acephalocystis,* the *echinococcus,* and the *cysticircus.* The term *hydatid* is likewise applied to the cysts not uncommonly found in the *plexus choroides;* to those which either singly, or in numerous association, are found more or less imbedded in the glandular substance of the kidneys; to the serous and mucous cysts, which constitute subordinate cysts in various cases of ovarian dropsy and other similar tumours. It is also applied to those vesicular bodies which are occasionally expelled from the uterus, and which bear some slight and imperfect resemblance to blighted bunches of grapes. The term *hydatid,* thus loosely employed, may possibly not be accompanied by any confusion of ideas in the mind of the person using it; but in many instances it has been so, and a doubtful or confused idea must necessarily be conveyed to the mind of the reader or hearer.

The word *tubercle,* evidently implying a small tumour, and its derivatives *tubercular* and *tuberculous,* afford a striking example of the employment of the same word to convey different meanings. Sometimes it is employed with reference to the form and size of the body described, as when we say a *scrofulous tubercle, a scirrhous tubercle,* and *a melanotic tubercle.* At other times, the term is designed to convey a particular idea of the material of which the body spoken of is composed, and is therefore used whether the body be small or large; whether it possesses a rounded figure, or is diffused in the form of an irregular mass. In the latter sense it is used by Laennec, Beclard, and Andral; by some other persons it is used occasionally in both senses. The word *scirrhus* as I have before remarked, is sometimes used to designate a particular and fatal disease; and at other times it merely implies that considerable induration has taken place.

The word *hæmatome,* implying a bloody tumour, is obscure and indefinite, not because it is employed in different and distinct senses, but because it points to a character which cannot be properly employed as a ground of distinction. Thus *an aneurismal sac* is a tumour containing blood. The capacious cells, which occur in some cases of fungoid disease, may be filled with blood, or bloody serum, and constitute a *hæmatome.* A simple serous cyst may also have its contents become bloody, and constitute another variety of *hæmatome.* Again, the vesicles of De Græfe are sometimes greatly distended by blood and bloody fluid, and thus become instances of *hæmatome.* Extravasations of blood may also take place in parts well supplied with that fluid, and constitute a *hæmatome,* or bloody tumour, as it is sometimes seen in the thighs and other muscular parts.

Without prolonging this article by a lengthened discussion of the subject of nomenclature, it may not be out of place to urge the importance of acquiring clear ideas respecting morbid conditions as they actually present themselves, and of cultivating the art of describing them with accuracy and precision, rather than seeking to fill the memory with a host of technical terms which can scarcely serve any other purpose than an useless display of erudition.

There are some conditions of parts deviating from the healthy state which require to be noticed, although they do not appear as characteristics of any of the sections into which pathological conditions have been divided in the arrangement just exhibited. They have not been employed as distinctive characters, because they may occur under different sections.

Preternatural softening of textures.—This condition may occur under various circumstances, and in various modes. It may happen to parts undergoing progressive wasting from the removal of the dense or solid parts, as sometimes happens to the bones of old persons, whence their fragility, as especially seen in the neck of the thigh-bone.

It may also take place in conjunction with preternatural or excessive growth, the textures not having as yet acquired the firmness which interstitial deposit ultimately gives to them. Thus, the brain of a child affected with hypertrophy, is apt to be soft and flabby. The bones sometimes exhibit a partial hypertrophy, in the early stage of which they are preternaturally soft, although they may ultimately acquire the ordinary firmness. Most newly-formed parts possess a softness of this description. We see this in the granulations produced in the formation of a cicatrix, in the callus which unites the fractured extremities of bones, and also in the early stages of exostosis.

The most numerous and remarkable instances of softening doubtless occur amongst the phenomena dependant on inflammation. The afflux of blood and other fluids, which is one of the first effects of inflammatory irritation, by increasing the proportion of fluid parts, causes a state of softness somewhat like that of newly-formed parts; but the tension with which these fluids are contained in the inflamed texture, not unfrequently during life, masks the softening which has been produced. The most important softening produced by inflammation is that which takes place when the process has been longer in operation; a portion of the solid material appears to be removed by interstitial absorption, whilst whatever new deposit takes place, as the product of inflammation, is a soft, if not a fluid material. It would also seem that during the existence of active inflammation, the original solid parts really have their cohesion impaired and become soft. Whether this depends on the suspension of the ordinary nutrient process, on an influence exerted upon the texture by the fluids of the part in consequence of altered properties in them, or on the diminished resistance in the solids themselves, with reference to the solvent power of the fluids, must at present be a matter of pure speculation which does not affect the fact itself, which may be brought about by one or all of these causes. Illustrations of this kind of inflammatory softening may be seen in all the numerous cases in which death takes place, preceded by some acute local inflammation. It may be seen in all the tissues,—not unfrequently rendering them susceptible of division without the use of a knife; but it is most remarkable and general in the cellular membrane, not merely allowing the easy separation of part from part, but also admitting of the subdivision of parts themselves; thus, recent carditis allows of the ready separation of the muscular fibres of the heart amongst themselves. The coats of an inflamed intestine are often still more readily separated, and many feet of mucous membrane may, without resistance, be torn from the peritoneal and middle coats. The effect of inflammatory softening upon the arteries and capillaries of an inflamed part, constitutes a very remarkable and important phenomenon. If we examine with a moderate magnifying power the small but injected vessels of an inflamed part, on which its preternatural redness depends, we shall often find that these minute vessels have lost their defined outline, and by giving way to distension at some particular points more than in others, occasion an irregular and spotted appearance of the injected surface. The minute vessels thus weakened are also of so soft a texture, that the slightest force is sufficient to rupture them; indeed, it would seem that this sometimes takes place spontaneously, and extravasation of blood is the consequence. This softening of the vessels may, therefore, thus become the cause of the admixture of blood with the solid or fluid products of inflammation, as in the case of hæmorrhagic pleurisies mentioned by Laennec and others. The most important softening of the vessels is that which takes place when the product of inflammation is susceptible of organization, since it would appear that the minute extravasations to which it gives rise are the commencement of the new or elongated vessels by which the new texture is to be nourished. This interesting phenomenon in the process of inflammation does not appear to have received all the attention which it deserves, and the production of vessels in coagulable lymph, which is in process of becoming organized, has in consequence been made the subject of curious speculations. It has been supposed that vessels were spontaneously produced in the organizable material, and made their way to the vessels of the original structures with which they found means to inosculate, and wandering bubbles of air passing through the plastic material, have been referred to as the agents by which the canals destined to become blood-vessels are formed.

Softening of textures, as the result of inflammation, instead of being a step to future organization, and, consequently, subservient to the preservation of the life of the part, is sometimes more closely allied to sphacelus, and may indeed be regarded as the commencement of that state. We see this kind of softening in muscles and other soft parts which have received severe contusion, and are about to slough. The lungs, liver, spleen, and other internal organs, when they have been the seat of a severe and fatal inflammation, are often found in a state of softening, which appears to be of this kind—the most striking examples of which are, perhaps, to be seen in the pneumonia of the dying, and in that condition of the spleen which is common in pernicious fevers.

When sphacelus or gangrene has actually taken place, softness, marked by great lacerability, is the notorious consequence. There are other cases of softening probably allied to some of those which I have just enumerated, which it seems necessary to mention, since the mode in which they are brought about is not very apparent, and the existence of any thing like inflammation in their production may be questioned. I allude to the softening of inter-articular cartilages, and of the inter-vertebral substance, and to some forms of softening of the brain, which seem to belong to this class. In these instances, the vitality of the parts is evidently reduced; but the effect of a preternatural stimulus, which is, perhaps, essential to unequivocal inflammation, is not to be discovered in the softened part, although it may be very apparent in some of the neighbouring parts.

The opposite state, or preternatural hardening, may, like preternatural softening, be produced in a variety of modes. It sometimes concurs with the wasting of parts; the fluid and soft parts being removed, whilst the solid are not only more or less left behind, but are brought into closer approximation, as we see in the round ligament of the liver, and in the remains of the umbilical arteries and urachus. It may also concur with hypertrophy and perversion of form, as in hardening of the spleen, and hardening of the cellular membrane and skin; but, in these cases, the inflammatory or other process affecting the intimate texture of the parts is more important than hypertrophy, or distortion. It is as the result of inflammation that we meet with the most frequent, and perhaps the most important instances of induration.

As inflammation has been already described as the prolific source of a variety of forms of softening, I must offer a few remarks respecting its mode of operation in producing the opposite effect. In recently inflamed parts, the induration may be rather apparent than real, since the fluids may be increased, and the solids weakened, the increased resistance being merely the effect of tension: in this way injured limbs often feel hard from mere effusion: some forms of *œdema durum* appear to be of this description. When we have a real induration of parts resulting from inflammation, it is, in general, not an immediate effect, but the result of a process requiring more or less time for its completion; the product of inflammation has been poured out, soft indeed, in the first instance, but being susceptible of becoming a permanent tissue, it has united with that in which it has been deposited, and participated in its organization; but when this is accomplished, like other newly formed parts, it wastes, its vessels contract, the fluid parts are removed, whilst the solid parts are brought into that closer union on which induration essentially depends. This induration of the superadded product of inflammation, not unfrequently, also occasions that of the original structure in which it is deposited: the original structure being compressed by the new, with which it is implicated, likewise contracts, and, in contracting, becomes indurated: there is, therefore, with this induration of an organ, a real diminution of size, notwithstanding the additional substance which inflammation has occasioned. The liver furnishes the best and perhaps the most frequent specimens of this induration which seems to be common to all our organs: the induration of the brain, described by Pinel, jun., Rostan, and others, appears to be one of the instances of it.

The most striking instances of induration, which take place as a consequence of inflammation, are those in which the affected structure becomes penetrated with earthy matter, constituting what is commonly called ossification. There are, however, two very different states to which this term is applied. In the one, the indurated structure has the organization, as well as the composition of bone; in the other, the latter only; and may, therefore, with more propriety, be termed petrification, as distinguished from ossification.

Induration is the common and distinctive characteristic of one form of disease of that class to which most, if not all, malignant diseases belong. It is, in fact, so striking an attribute of true scirrhus, that formerly when the language of morbid anatomists was less exact than at present, various indurations of a totally distinct nature were confounded together under this term. It is not only the new growth which is remarkable for its hardness, but also the neighbouring parts contaminated by the disease often become similarly affected.

Colour is another quality of diseased parts, which is well worthy of careful attention, although by no means adapted to become the basis of classification, since a similarity of colour would bring together derangements in every other respect essentially distinct. Nevertheless, in some very striking cases, a well marked peculiarity of colour seems to have given the principal interest to certain affections, as in the case of melanosis, cirrhosis, morbus-cœruleus, chlorosis, and the like. The principles on which these varieties of colour depend, appear only to a very limited and imperfect extent, to have arrested the attention of pathological anatomists.

The division into malignant and more malignant, although of great importance, with reference to the patient, and the symptoms under which he labours, affords a very imperfect distinction with reference to anatomical character. It has already been stated, that most, if not all, malignant structures belong to one of the classes enumerated in the table, in consequence of a striking resemblance of structure; but there are other productions manifestly exhibiting these peculiarities, which could never be regarded as participating in the malignant character. Take, for example, some of the encysted dropsies of the ovaries, or their neighbourhood, and some tumours in the female breast.

The history of the cultivation of Morbid Anatomy is so intimately involved with that of the progress of Medicine and Surgery, that it can be of little importance to sketch it in a separate form. Those who feel an interest in this subject may consult the works of Cruvelhier and Lobstein for a short exposition of what has been done expressly for the cultivation of this branch of pathology. Suffice it to say, in the words of Rostan:—"When a superstitious respect for the tomb forbad to seek in the bodies of the dead for knowledge, which might redound to the advantage of the living, most diseases were regarded as essential and general; and it was imagined that they did not leave any trace behind them. At length, when the light of philosophy had illuminated civilized nations, it became allowable to carry a scrutinizing inquiry into the lifeless human body; and those remains, which were once the prey of worms and corruption, became the prolific sources, whence the most useful truths proceeded.

"From that time, diseases, which had previously only been regarded as derangements of function, were recognised as organic alterations. Mere symptoms lost their ancient importance, and were only valued as indications of organic derangements."

Since this happy revolution in opinion has taken place, Morbid Anatomy has been cultivated with zeal, and its advancement has proceeded with accelerating rapidity. Several important general treatises, and a still greater number of admirable works, elucidating the derangements of particular parts, have been published both in our own and in foreign languages. In fact, whatever may have been the extent of lucrative practice, or ephemeral popular celebrity, which individual members of the medical profession may have acquired by superior address, or the zealous advocacy of particular theoretical speculations, or by modes of treatment, rendered attractive by the promise of extraordinary success, few, if any have assured to themselves permanent reputation among their brethren, (the only competent judges,) whose labours have not been conjoined with researches, in which pathological anatomy has been concerned; whilst very many, who have devoted the most laborious and indefatigable attention to this department, have made it the broad and sure basis on which they have raised the superstructure of their lasting fame. I need only mention the names of Morgagni, of Voightel, of Portal, of Baillie, of Bayle, of Laennec, of Cruvelhier, of Andral, of Louis, and of Billiard, and last, but not least, of Sir Astley Cooper, of Dr. Bright, and of Dr. Carswell.

It is not, however, as the means of acquiring reputation, though well merited, that the advantages of Morbid Anatomy may be most strongly urged; but rather as one of those essential requisites, without which no one can expect to be able to discharge his professional duties with satisfaction to the public, or with an easy conscience to himself.

Although Morbid Anatomy, in the wide range allotted to it in this article has been described as including, not the mere dry detail of numberless repulsive and unconnected facts, but, on the contrary, an assemblage of interesting phenomena, developing some of the most wonderful operations of nature, yet it is in connection with other departments, that its vast importance and value are conspicuous. It lends to Physiology that assistance, for which no artificial method of inquiry can supply an adequate substitute. As the only means of throwing certain light upon internal diseases, it is both the basis and the test of diagnosis; and those who neglect this test of their diagnostic powers, are blindly groping in the dark, whether they are conscious of their situation or not. Morbid Anatomy does not merely enlighten us with respect to those cases of disease which we have unsuccessfully endeavoured to combat: it makes us aware of dangers, which we must be on our guard to avert; and it points out to us the path which Nature takes to reduce to a permanent and comparatively healthy, or unimportant condition, those derangements, which do not admit of perfect restoration; a course in which Nature may be aided, but in which she cannot be opposed with impunity. These advantages are not the only rewards held out to excite to the diligent cultivation of a subject, which, when first approached, may well be thought repulsive. Without doubt, there yet remain important discoveries to be made in Morbid Anatomy in connexion with every organ of the body. It is not every individual, or every year, which will furnish a discovery like that of Dr. Bright, with respect to a particular derangement of the kidneys, or that of Dr. Davies, in elucidation of the pathology of *phlegmasia dolens*.

But by sedulously applying ourselves to the subject of pathological anatomy, we shall be surprised at the frequent occurrence of discoveries of greater or less importance ; and at the fair promises of the field yet open to future research. It is not only in the examination of rare and remarkable cases, or even in studying the various appearances exhibited in the pathological condition of a particular organ, that much may yet be done in this department. There is abundant scope for further labour with respect to the commonest diseases by which our bodies are assailed. All of these call for investigation on a more extensive scale. The collection of cases must not only be numerous, but in all a faithful record must be kept, of the age, sex, temperament, occupations, and habits of the individual ; of the time of year, of the symptoms, and of the treatment and its effects. These particulars must not be confined to the unsuccessful or fatal cases, but should also be extended as widely as possible to those in which the issue has been favourable. With respect to the fatal cases, not only the organ principally affected should be examined, but also the condition of those apparently unconnected with it, should be observed and noted. The aggregate of such observations would become the basis of a statistical inquiry, which, whilst it would do away with many preconceived and erroneous notions, would also bring to light many curious, but unexpected and important results. This process constitutes the numerical system so strenuously advocated, and ably put in practice by that distinguished pathologist, Professor Louis. It would be an injustice to this system to confound it with medical reasoning, and medical philosophy. It is the means, or instrument, (and the most powerful instrument, too,) by which those facts are to be obtained, with which alone a sound medical philosophy can be constructed on the ruins of those systems and speculations which this same powerful engine must level with the dust.

In Paris, a band of youthful and devoted pathologists have combined to bring this engine into work ; and I would fain indulge the hope, that the energies of the rising members of the medical profession in this country may be animated by a generous rivalry, which will not suffer them to be surpassed.

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(*Thomas Hodgkin.*)

ANATOMY, SURGICAL. Under this term modern writers have endeavoured to describe that branch of anatomy which refers principally to the size, form, connexion, and relative situations of the parts contained in divers sections, or regions of the human body ; hence also various other denominations which are now generally understood, viz. anatomy of relations, anatomy of the regions, regional, graphical, topographical anatomy, &c. ; some prefer calling it medico-chirurgical anatomy. Many objections might easily be made to these expressions ; but without dilating upon this subject, we shall at once follow the example of two able authorities, Allan Burns, and Dr. Colles, and content ourselves with the terms which head this article.

It has been asked if there really were such a distinct branch of anatomical science as that named surgical anatomy ? or, in other words, whether descriptive anatomy does not embrace every particularity of that science which can be useful to the surgeon ? A good anatomist, no doubt, is perfectly conversant with all the parts of the human frame, their size, form, and uses ; he can lay bare the most hidden artery with the utmost facility ; he can open the most difficult joint with entire confidence and great rapidity ; to such a person, surgical anatomy will rarely be of importance. But this does not diminish the usefulness of that study ! To the profound anatomist, a knowledge of the accurate relative situations of parts contained in a region is the most difficult to acquire; he may recollect the precise course of the smallest branch of a vessel, or the most minute twig of a nerve; he may know every origin and insertion of the muscles when taken separately, and still he may not remember the exact relative situations of the same parts, when considered collectively. We feel convinced (from actual experience) that, as far as the ordinary practice of surgery is concerned, this branch is the perfection of anatomy! Without it the surgeon will rarely, if ever, be enabled to cut down upon a deep seated organ with as much security and precision as if the parts to be divided were transparent; besides, it will readily be allowed by all professors of anatomy, how seldom a perfect knowledge of that study crowns the student's labours, especially in England, where still, unfortunately, so many obstacles are thrown in his way; for this reason, also, would it not be advisable, instead of compelling the student to aspire to the acquirement of minute anatomy, to direct his attention more particularly to surgical anatomy, which, on account of its practical application, will ever be better engrafted in his memory? It would be well if hospital surgeons were to precede all the great operations with an anatomical display of the similar region or regions upon which they are about to act; they would thus excite a deep interest in the operation, and confer great benefit on the patient, the pupils, and themselves.

Much angry discussion has lately arisen in Paris, concerning the claims to the priority of idea regarding the publication of complete treatises upon surgical anatomy. We have not in our possession all the data upon which to found an impartial judgment; a point, which however is the less important, as it will be discussed elsewhere (History of Surgery). We may safely bestow great praise upon Allan Burns, Colles, J. and C. Bell, Harrison, in this country; on Beclard and Dupuytren for their excellent lectures, and to M. M. Velpeau, Blandin, Gerdy, Edwards, Bourgery, for their interesting labours. In Italy, Germany, and America, works have likewise been dedicated to this subject, which will receive due attention in future papers. The great object of surgical anatomy should be to neglect all those minute details which are found in comprehensive treatises, for the more perfect acquirement of the exact forms, sizes, connexions, and relative situations of the parts contained in the regions; for instance, the surface of the body must be scrupulously examined; the numerous external elevations and depressions are of considerable interest to the surgeon, affording him frequently the most faithful rules for the execution of operations. After the surface of the region, the deeper parts will next occupy the student's care; here, nothing should arrest his observation which is not of practical use. It will be our great aim, after the anatomical investigation, to point out all useful information respecting the various pathological conditions of the regions last described; this will tend much to lessen the great perplexity which the young surgeon has so frequently to encounter in his first operations. Each article will thus be made to conclude with much important matter, which the reader would in vain look for, in ordinary works on surgery and anatomy. These articles will contain no views of *transcendental* anatomy, no discussion of vain theories, or obsolete operations; a plain and practical description of the regions of the body must alone be expected: the student may follow us with his scalpel and subject before him—the best and shortest way to make himself master of surgical anatomy. Many writers have given themselves great trouble about the division of the body into sections or regions; all have differed. M. Velpeau has made many which are neither natural nor of any practical benefit; M. Blandin's method is less arbitrary. As far as possible, we intend following the great natural divisions of the body, and propose calling them by the old names, thus:—Head, face, mouth, palate, arm, forearm, elbow, knee, groin, &c. &c. The most important articles will be accompanied by wood-cut sketches, drawn from nature. In the execution of this task, we shall endeavour to guard against the errors of our predecessors, who, by attempting to represent too many objects in their engravings, have frequently thwarted their end, and rendered them extremely confused.

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(*Claudius Tarral.*)

ANCHYLOPS. See Ægylops.

ANCTERES, obsolete, *ἀγκτῆρες*, fibulæ or clasps, by which the lips of wounds were formerly kept together.

ANEURISM, (*εὐρύνω, dilato,—ἀνεύρισμα*, Gr.; *Pulsadergeschwulst*, Ger.; *anevrysme*, Fr.) is a generic term applied to a tumour, formed either by the dilatation of the coats of an artery, or by blood effused from a rupture or wound of an artery, into the contiguous cellular structure; the term is also applied to a dilatation of any of the cavities of the heart. Under the term aneurism has also been comprehended several diseases, which have no common character, except that they involve the arterial system. Thus, besides the *true* and the *false*, there are the *varicose* and *anastomosing aneurisms*, the *aneurismal varix*, and the *arterial varix*.

The *true* or *encysted* aneurism, properly so called, (*aneurisma verum sacciforme*,) is a tumour formed by the dilatation of a portion of an arterial tube, and the aneurismal sac may be formed by the dilatation of the whole of the tunics of an artery, the two external tunics may give way, or one or both of the internal tunics may be ruptured, the cellular coat of the vessel alone forming the parietes of the tumour, and preventing the effusion of blood amongst the surrounding parts. Some pathologists, and particularly Scarpa, conceived that an aneurism was always formed in consequence of a rupture of some of the tunics of an artery; but it has been clearly proved by numerous dissections, that an aneurismal swelling may be formed without the rupture of any of the coats, and merely by the dilatation of all the tunics of the vessel. When an aneurism is of recent formation, and of a small size, the dissection of the tumour often exhibits a simple dilatation of all the arterial coats; but when the aneurism is large, the internal and fibrous coats of the vessel, or the fibrous coat alone, are lacerated.

The different modes by which an aneurism is formed, or the different conditions of the coats of the artery in an aneurismal sac, are illustrated in the annexed diagrams.

Fig. 54.

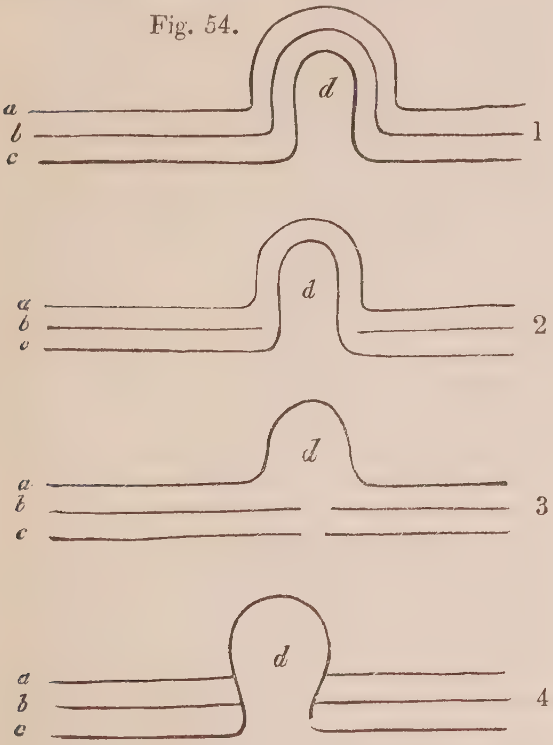

Fig. 1, *represents an aneurism wherein each of the three coats of an artery* (*a*, *b*, *c*,) *are equally distended, and form the parietes of the sac* (*d*).

In fig. 2, *the parietes of the aneurismal sac* (*d*) *consist of the internal coat* (*e*), *and external coat* (*a*), *the middle coat* (*b*) *having been ruptured.*

In the third, the aneurismal sac (*d*) *is formed merely by the external or cellular coat* (*a*); *the two internal tunics having been ruptured.*

In the fourth, the sac (*d*) *is formed by a distention or hernia of the internal tunic* (*c*), *the external coat* (*a*), *and middle coat* (*b*), *having been both ruptured.*

An aneurism, when situated near the surface of the body, or an external aneurism, makes its appearance at first as a small circumscribed pulsative and colourless tumour, of a globular form, compressible and elastic, attended neither with pain nor inconvenience, disappearing on the application of pressure, and reappearing on its removal. The pulsations of the tumour are synchronous with those of the heart, and if the vessel be compressed between the tumour and the heart, the pulsation of the aneurism ceases, but is again renewed when the pressure is removed. On the other hand, if pressure be applied on the artery on the capillary or distal side of the aneurism, the force of the pulsations of the tumour is increased.

As the tumour enlarges, the pulsations become less and less distinct, and ultimately but a slight thrill is communicated to the hand; and when the tumour has existed for a very long time, and has attained a great size, all pulsation may disappear. Neither can the swelling be now made to subside on the application of pressure, a change which is caused by the coagulation of the blood and the effusion of fibrine within the aneurismal sac.

As the disease advances, the skin covering the sac, stretched and attenuated, turns livid, inflames, and sometimes presents gangrenous spots; the subcutaneous veins become varicose, and if the aneurism be situated in one of the limbs, the whole member becomes cold and œdematous. In this advanced state, the parietes of the sac, becoming so attenuated as to be unable to resist the impetus of the blood, soon give way, and an opening is formed in the gangrenous portion of the skin, which involves the cyst of the aneurism. Should the aneurism extend into a mucous canal, the termination will take place in the same way as on the cutaneous surface; and if it approaches a serous cavity, the sac will either crack or ulcerate. However, in the greater number of instances, an aneurismal tumour advances towards, and ultimately appears at the cutaneous surface.

When a rupture of the tumour has taken place, the coagulated blood contained within it prevents the profuse outpouring of the fluid blood, so that the stream is not continuous, but is discharged at intervals, each jet becoming more profuse and alarming; a fatal hæmorrhage does not immediately take place unless the opening in the sac be large, and the clots of blood are quickly displaced, so that there will be no obstruction to the escape of the fluid blood. Sometimes the blood from the aneurismal sac, in place of bursting through the skin, or into a mucous canal, or serous cavity, escapes amongst the surrounding soft parts, thus constituting the diffused or *false* aneurism.

When the parietes of an aneurismal sac have thus given way, sometimes the tumefied parts become of a livid colour, the skin sloughs, and blood, partly fluid, and partly coagulated, continues to be discharged. The cellular issue being now infiltrated with blood, inflames and sloughs, the discharged clots assume a bright red colour, and at length, fluid arterial blood is poured out. These changes make their appearance with a rapidity proportioned to the facility with which the blood escapes from the ruptured sac, and as the opening in the sac is generally small, the blood escapes slowly, making its way through the cellular membrane to a distance more or less remote, and forming a tumour, the true nature of which it is often not easy to detect; or at a more advanced period, the sac which has been formed of the cellular coat of the diseased vessel now gives way, and the boundary or sac of the aneurism is formed of the cellular sheath of the artery and the surrounding soft parts, all of which have adhered together and become consolidated, and it is only when the sac has burst before such consolidation of the sheath and adjoining soft parts have become sufficiently strong to resist the force of the blood's current, that the fluid blood is diffused amongst the surrounding parts.

Aneurisms produce effects which vary according to the nature of the textures surrounding them, and the regions of the body in which they occur. The pressure of the tumour on particular nerves creates pain along the course of those nerves, gives rise to œdematous swelling by compressing the veins and lymphatics, causes the skin to inflame, and when of long continuance destroys even the contiguous bones.

Aneurisms, when situated near any of the great cavities, sometimes extend into those cavities, and prove fatal by the derangement which the tumour, from its bulk, produces on some vital organ. An aneurism may likewise destroy life by the incessant pain, or by the long duration of the disease producing a gradual extinction of the vital functions.

Aneurisms, however, do not always proceed to a fatal termination; and it happens by no means unfrequently that processes are set up by Nature which effect a *spontaneous cure* of the disease. The tumour ceases to pulsate, diminishes in size, becomes harder, and finally disappears altogether, or is reduced to a more or less firm and solid mass.

The spontaneous cure of an aneurism may take place in no less than *five* different manners, and the principle or the processes which Nature employs for the cure of the disease, is in all of them the same, the parietes of the sac being strengthened by, or the whole cavity filled with, a fibrinous concretion.

1. The first and the most common of these spontaneous processes of cure is effected by the aneurismal sac being so filled up and strengthened with concrete fibrine, that all danger of a rupture of the sac is removed, whilst at the same time the original canal of the vessel remains pervious, and carries on the circulation of the blood.

2. In the second process by which an aneurism may undergo a spontaneous cure, the sac is not only filled with concreted fibrine, but the canal of the artery is obliterated.

3. An aneurism may likewise undergo a spontaneous process of cure by the tumour acquiring such a size and position, that by its pressure on the trunk of the artery, either on the cardiac or on the capillary side of the tumour, the sides of the artery are brought into contact and adhere. (*Home.*)

4. An aneurism may also be cured spontaneously by a process of suppuration in the sac, both the sac and the artery above and below the tumour having previously been filled with coagulum. In such a case, the integuments inflame and adhere to the sac and then ulcerate, and those portions of the coagulum which cannot be removed by the process of absorption, are ejected through the ulcerated opening, allowing the cavity of the sac to be filled up and obliterated by the process of granulation.

5. The fifth mode of spontaneous cure has been observed from the bursting of the tumour underneath the common integument, and the artery becoming obliterated by the pressure of the effused blood. (*A. Cooper.*)

I have observed that the principle on which an aneurismal tumour can be cured by any of these spontaneous processes is the same—all of them depending on the effusion of concreted fibrine within the sac, or both within the sac and a portion of the artery adjacent to the aneurism; and which fibrinous concretion is caused, or is permitted to be formed, whenever the circulation of the blood within the sac becomes preternaturally languid.

On the circulation of the blood in the sac, or in a portion of the artery as well as in the sac, being thus prevented by a fibrinous concretion, another process is afterwards instituted; the former being only to answer a temporary purpose. The concreted fibrine is ultimately absorbed, and the aneurismal sac, or both the aneurismal sac and the artery from whence it originates, gradually contract,—the sac becoming a small fleshy tumour, and the artery an impervious tube. Petit describes the remains of an aneurism of the carotid artery, which had originally been the size of an apple, and after having undergone a spontaneous cure, was found, after death, not larger than an olive.

Whenever the spontaneous cure of an aneurism has been effected by any of the aforesaid ways, it sometimes happens, even after so desirable a change has taken place that the bulk of the tumour alone, in certain situations has continued to cause alarming symptoms, and even to prove fatal. Thus aneurisms at the arch of the aorta, in the arteria innominata, and the roots of the carotids, I have repeatedly seen cause death, even where they had not acquired a very large size, or where the sac was filled with fibrine and completely consolidated.

Fig. 55.

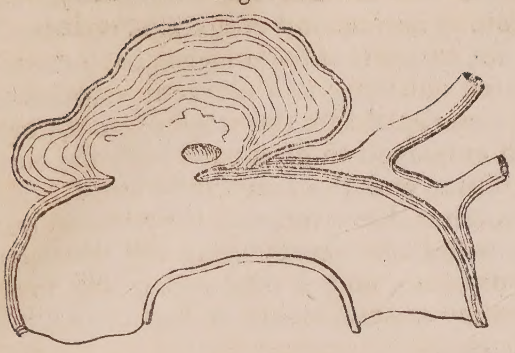

Fig. 55 *exhibits an aneurism of the aorta which has undergone a spontaneous cure by the first mentioned process; the sac is completely filled with laminæ of concreted fibrine, so that there was no longer any danger of a rupture of its parietes. There is a small cavity in the interior of the concretion which communicates with the aorta, and through this cavity, the blood passed into the arteria innominata, the origin of which is observed at the inferior part of the cavity. (Hodgson.)*

Fig. 56.

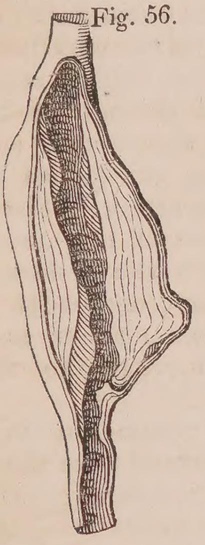

Fig. 57.

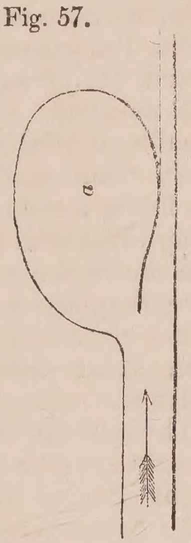

Fig. 56. *The whole circumference of the vessel has become aneurismal, and a spontaneous cure has been effected by the second process which was described. The sac being filled with a laminated fibrinous concretion and a canal left in the centre of the concretion, through which the blood had continued to circulate. The canal is seen of an irregular form, and in some places larger than the calibre of the healthy portion of the artery.*

Fig. 57, *is a diagram explaining how an aneurism may undergo a spontaneous cure by the tumor* (*a*) *acquiring such a form and position that by its pressure on the trunk of the artery* (*b*, *b*), *either on the cardiac or capillary side of the tumour, the sides of the artery are made to approximate.*

Fig. 58.

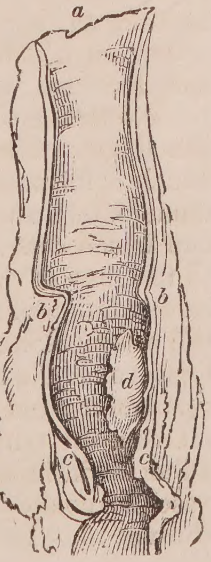

Fig. 58. *The upper portion of the femoral artery, in which the aneurismal swelling had become the seat of suppuration and sloughing. In this patient there was a large aneurismal tumour of the femoral artery, just where that vessel penetrates the triceps muscle. The integuments ultimately gave way from the enormous growth of the tumour; large masses of coagulated blood were afterwards discharged through the ulcerated openings of the skin, and an immense suppurating cavity was thus formed, the profuse discharge from which proved fatal. On dissection, it appeared that upwards of six inches of the femoral artery had sloughed off, and nature had plugged up both extremities of the vessel, by producing a contraction and thickening of the coats, and also the formation of an internal clot. a, is the upper portion of the femoral artery, which at b b, is considerably diminished, and from thence the canal becomes gradually narrower, until at c c, where it is greatly contracted, and terminates in disorganized cellular membrane. The internal clot d, is observed immediately above this ulcerated orifice, and floats loose in the tube of the artery.*

The aneurismal Sac has usually a form more or less globular, and sometimes emerges from the arterial trunk by a neck so slender as to give a pyriform or flask-like appearance to the swelling, (fig. 59).

Fig. 59.

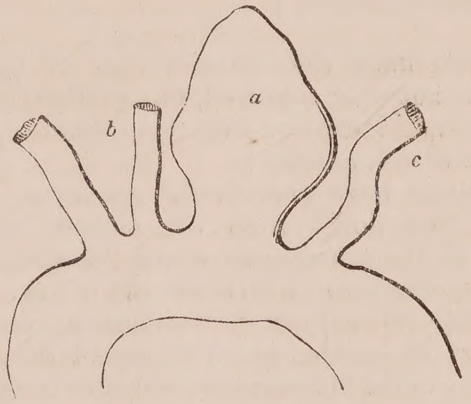

Fig. 59 *represents an aneurism with a very narrow neck rising out from the arch of the aorta. The tumour* (*a*) *of a Florence flask shape emerges from the aorta between the roots of the left carotid* (*c*), *and left subclavian* (*b*).

On examining the coats of an aneurismal artery we find that they have become altered in their structure. The cellular coat is usually thickened, and adheres more or less to the surrounding cellular texture. The proper fibrous coat is paler and less elastic, and the internal coat is more brittle and even more easily torn than in the natural state. Calcareous or chalky-looking matter is frequently deposited between the coats, and osseous scales are sometimes observed covered by the inner tunic; or that coat is destroyed, and the bony matter is in direct contact with the circulating blood. All these changes in the structure of an artery occur, however, independently of any aneurismal swelling, and usually exist prior to the formation of an aneurism. It is, in fact, the diseased state of the coats of the artery which makes them liable to give way, and become aneurismal.

The opening, by which the sac communicates with the artery, is generally of an irregular form, and varies in size; being sometimes very small, sometimes so large as nearly to divide the artery, and sometimes this opening is so large that no distinction can be observed between the parietes of the tumour and those of the artery, the internal membrane of the sac appearing to be continuous with that of the vessel.

Fig. 60.

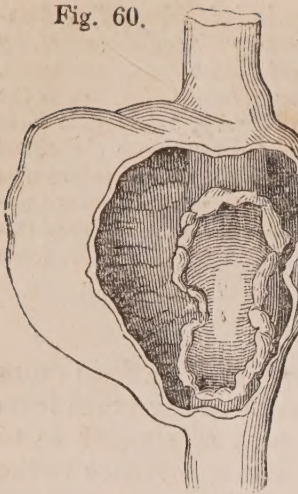

Fig. 60. *The destruction or rupture of the coats of an artery, which leads to the formation of an aneurism, is here illustrated: the thoracic aorta communicates with a sac that had burst into the lungs, the internal coat of the artery was thickened, and at the part where it communicated with the aneurismal sac a portion of the circle of the internal and middle coats had been ruptured and destroyed by ulceration, the lacerated edges being separated to a considerable distance. The external or cellular coat is stript from the fibrous coat to a considerable extent, and forms the sac.*—(*Hodgson.*)

Sometimes the interior coat of the artery is not only ruptured, but portions of that tunic hang loose like fringes, so that they float in the blood. (*Haller*)

"Some have conceived," observes Laennec, "no doubt from the smooth appearance of the opening by which the aneurismal sac communicates with the cavity of the artery, that the internal membrane forms a protrusion or sort of hernia, which extended through a rupture of the fibrous tunic, and after being gradually distended, lines the whole of the internal surface of the aneurismal sac, whilst the cellular coat of the artery forms the external covering. Dubois and Dupuytren adopted this opinion, and they presented some anatomical preparations to the Society of the Faculty of Medicine, to prove that in certain cases the internal membrane extends through the opening of communication, and lines the internal surface of the sac some distance from the opening."

It sometimes happens that when the internal coats of an artery give way, the blood, in place of distending the cellular covering of the vessel corresponding to such rupture, and there forming a common aneurismal tumour, insinuates itself between the cellular and fibrous coats of the vessel, and then becomes extravasated, sometimes to a considerable extent, forming what is called by Laennec, a *dissecting aneurism.* In one remarkable case of this kind the blood was driven through the internal and fibrous coats, and dissected the fibrous from the cellular coat for the space of four inches, and then returned through another rent in the canal of the artery. This new channel of the blood had a coating of coagulable lymph, which had a smooth surface, and the rent in the tunics of the artery was so large as to transmit the greater portion of the blood, so that the original tube had also its direction altered from the compression of the swelling, the newly-formed canal having assumed its place.

Contents of the Sac.—Besides the changes which have taken place in the tunics of an aneurismal artery, the sac will be found to contain two distinct substances,—coagulable lymph, or fibrine, and coagulated red blood. I am not aware that pathologists have distinctly pointed out these two different substances in the aneurismal sac, the word *coagulum* having been employed to designate both the concreted fibrine and the coagulated blood. It is of importance, however, that they should be discriminated when considering the treatment of the disease; and I shall endeavour to show that they are the result of two very different processes.

Fibrine.—When the fibrinous concretion is examined, it is found to consist of numerous concentric laminæ, which are more or less easily separable from one another, and firmer in proportion as they approach nearer to the coats of the sac. The laminæ of fibrine which are in immediate contact with the blood circulating in the sac have generally a flocculent appearance, and have coagula of red blood mixed with them. But in some aneurismal tumours the concreted fibrine has its interior surface smooth and polished, being lined throughout by a membrane which has the appearance, as already mentioned, of being continuous with the lining membrane of the artery. The sac being lined with a membrane of this description shows the power which the system has of reproducing a serous membrane under particular circumstances, in like manner as has been often observed with regard to other textures.

Though the fibrinous concretion in an aneurism can be easily separated from the sac, yet it adheres closely to its internal surface, and I have every reason to believe that there is a vascular connexion existing between them. Morgagni, indeed, doubted the possibility of aneurismal concretions being produced by a mere stagnation of the blood.

Neither the precise nature of the connexion which exists between the aneurismal sac and the concretion, nor the nature of the process by which such concretions are formed, have been accurately pointed out by pathological inquirers. There is evidently a great difference, however, in the anatomical characters of a common clot of blood and a fibrinous concretion; and the coagulated lymph, or fibrine, which is deposited in an aneurism appears to me to bear a strong analogy to the internal clot found in an artery on which a ligature has been placed, and likewise with those polypiform concretions which are formed within the cavities of the heart. Besides the coagulum of blood which is formed within the canal of an artery, immediately after the application of a ligature, and which acts merely as a temporary barrier to the flow of the blood, there is subsequently an exudation of fibrine from the internal coat of the artery, commencing from the place of the ligature, and extending as far up the canal as that point from which the first branch is sent off from the trunk of the artery. This fibrine adheres intimately, and appears to have a vascular connexion with the internal coat of the vessel. In the Hunterian Museum there

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